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THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

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THE FURLOUGH WANDERINGS OF A DIRECTOR OF AGRICULTURE.

By J. MACKENNA, M.A., I.C.S.,

Director of Agriculture, Burma.

Introductory.

In 1905 when it was decided that a separate Department of Agriculture should be established in Burma, as in the other Provinces of India, the Local Government very considerately acceded to my proposal that I should take a year's furlough to make myself familiar with what was being done in scientific agriculture in Egypt, Great Britain and Germany. In this and the following articles I propose to record, in the hope that they may interest some readers of the Journal, the impressions formed during my "Wander jahr." These notes pretend to no great scientific accuracy, nor are they to be considered as scientific studies; they are intended to convey merely an idea of the equipment, and of the class of work which is being done at the better known research institutions in Great Britain and Germany. They are based on notes made at the time of my visit and on the various reports which were kindly given to me by the officers in charge of the different places visited. These reports are, for the most part, available to the general public; but my rambling notes may take their place for those who cannot easily have access to the published literature.

In the course of my wanderings, I saw many men and many places. It is, therefore, a matter of some difficulty to decide on a starting point for these wandering notes. The memory of Ghizeh, under the shadow of the mighty Pyramids and hard by the Sphynx "more wondrous and more awful than all else in

the land of Egypt," thrusts itself forward as deserving special prominence. The magnificent laboratories and institutes of Leipsic struggle for prominent recognition. The modest retreats of Kellner at Mockern and of Wagner at Darmstadt—world-famous both—these too stand out in bold relief. But when we have surveyed all with equal mind and given all their due meed of recognition, we feel that we can, with justice to our true feelings and without impartiality, fairly find our starting point in our own country; and so it is with Rothamsted that I shall start this series of rambles.

ROTHAMSTED.

In the village of Harpenden, and some 25 miles north of London, on the Midland Railway, is situated the world-famous Rothamsted Experimental Station. As the pious Mahomedan turns his thoughts to Mecca, so should the devout student of agricultural science, as he travels from London to Scotland (whence most of them hail), turn devoutly to the west as he speeds through Harpenden—for there is the Mecca of English scientific agriculture.

Rothamsted is not a thing of yesterday. It is 74 years since, in 1834, Sir John Bennet Lawes entered on occupation of the ancestral estate of Rothamsted, which he was to make world-famous as the centre of chemico-agricultural research. At Eton and Oxford he favoured the scientific side, and when he entered on his career as an agriculturist on the home farm at Rothamsted, he gave full rein to his natural inclinations and tastes. A chemical laboratory, fitted up in one of the best bed-rooms of the mansion house, was one of his first innovations; and the results of the quiet research here conducted, into the nutrition of plants, supplemented by pot and field experiments, were such that, in 1842, he determined to take out a patent for "Superphosphate." By this act he ranks practically as the pioneer of chemical manures. The result of this patent was not only a vast benefit to agriculture in general, but the commercial success of the discovery laid the foundations of a great fortune. In 1872 he sold his

manure business for the large sum of £300,000. Meanwhile, side by side with the commercial development, experimental research had been continuous on the Rothamsted farm, and any proved result was at once made available for the general body of agriculturists. Not only did his great researches bring him great riches but they earned also the gratitude of the farmers, whom they specially benefited. In 1853, a testimonial, practically national in its extent, was subscribed for, and, at Mr. Lawes' request, the greater portion of it was devoted to the construction of a new laboratory. Rothamsted is thus a monument, not only to its great workers but to the intelligent and reciprocal appreciation of the English farmer.

Other honours crowded upon him. The Sovereign showed Her appreciation of his work by conferring a Baronetcy upon him in 1882. France, Germany and Russia vied in doing him honour. The Universities of Oxford, Cambridge and Edinburgh all conferred upon him honorary degrees. Nearly every Scientific Society of any standing, either in England or on the continent, acknowledged in a tangible form its appreciation. The jubilee day of the Rothamsted experiments—July 29th, 1893—was a great day for Sir John Lawes and his famous colleague, Sir Henry Gilbert. The world of science—from members of the Royal Family to the smallest farmer—paid tribute to these great benefactors to agriculture. At last, in the 86th year of his age, and after a life of exceptional strenuousness which only his giant constitution could have withstood, he was gathered to his fathers. He lies buried at Harpenden, in the midst of the scenes of his life's work—leaving behind him a name which will never be forgotten in the annals of scientific agriculture.

One of the most delightful features of the relations of this charming personality with the general body of agriculturists was the reciprocity of feeling. If the agriculturist appreciated the experimental work being done at Rothamsted, Sir John was not behind in reciprocating this good feeling. He was absolutely magnanimous in his devotion to the simple toiler in the fields and splendid in his liberality. He early conceived the idea of

perpetuating the work by putting Rothamsted on a permanent footing. In 1889 he accordingly transferred the experimental fields and laboratory to a Committee, together with an endowment of £100,000. This strong and representative Committee—four nominated by the Royal Society, two by the Royal Agricultural Society, one each by the Linnean and Chemical Societies with the owner of Rothamsted,—form the Lawes' Agricultural Trust, who now control the Research Station.

The name of Sir Joseph Henry Gilbert ranks second only to that of Lawes. After a long training in Chemistry in London, Glasgow and Gniessen, he became, in 1843, the colleague of Sir John Lawes at Rothamsted—a colleague-ship which was only dissolved by the death of Sir John Lawes in 1900. This long partnership was happily referred to by Sir John Lawes at the Jubilee Celebrations at Rothamsted. He said, "When two people were joined together in marriage they could not part, because they were bound together by very solemn ties. But with regard to himself and Dr. Gilbert the case was quite different. Dr. Gilbert could have left him or he could have left Dr. Gilbert. Their connection, however, had lasted for more than fifty years. What was the cause? Nothing less than mutual love of the work they had been engaged in. He (Sir John) had delighted in the work from the beginning. All the time he could spare in the midst of many other responsibilities and duties he had given to the work. But with Dr. Gilbert it had been the work of his life. If it had not been for Dr. Gilbert's collaboration, their investigations would have been in a very different state to what they were then."

The partnership of these two famous men lasted for the long period of 57 years; nor would it appear to have been marred by the slightest friction. Their collaboration was perfect. The details of every experiment were worked out together and each worker was responsible for his own part of it; Sir John Lawes for the agricultural side; Sir Joseph Gilbert for the laboratory. Hence the excellence of the joint work. Like his distinguished colleague, Sir Joseph Gilbert had many academic and other

listinctions conferred upon him. He survived Sir John Lawes by only 16 months, dying at Harpenden on December 23rd, 1901, n his 85th year. "In death they were not divided." And so ended the greatest scientific combination that the world has, probably, ever seen.

The present Director is Mr. A. D. Hall, M.A. (Oxon.), and the Chemist, Dr. N. H. J. Miller, who has been connected with Rothamsted since 1887. Since my visit the staff has, I understand, been strengthened by the addition of Dr. E. J. Russell, the distinguished Chemist, formerly of Wye, whose work on soils is well known. All have already turned out a considerable quantity of work which ranks high in the estimation of scientific men. Mr. Hall has laid all agriculturists under obligation to him by his lucid account of the work at Rothamsted as recorded in "The Book of the Rothamsted Experiments." This should be owned and read by every one who wishes to acquaint himsel. with the wonderful work accomplished by Lawes and Gilbert. I have thought it advisable to give these biographical details because no one can think of Rothamsted without calling up the memory of Lawes and Gilbert. They were the apostles of English scientific agriculture, and the mention of Rothamsted must inevitably suggest their names.

In studying the Rothamsted field work, it should be noted that the object of these long-continued experiments is to discover "how a plant grows" and only indirectly to find the most paying method and manuring. What is aimed at is the discovery of general principles; to obtain knowledge that is true everywhere; research in the truest sense of the word; the application being adapted in particular cases to the peculiar conditions of the soil or crop being dealt with.

Before proceeding to an enumeration of the field experiments and to the indication of the more interesting results, there are one or two general matters which may be touched on.

In the first place Rothamsted does not fulfil the usually accepted idea of an experimental farm, *i.e.*, a homogeneous connected block divided into separate fields. Rothamsted is a

composite station consisting of odd fields taken out of the estate to suit the conditions required by its illustrious donor. There is nothing of the "ringed fence" about it. Hard by the central Laboratory and other buildings are two fields (Agdell and Barnfield), which are in the experimental area. These fall to the east of the mansion house of Rothamsted. To the south-west lies a grass park where experiments are also carried out, while three of the principal fields—Broadbalk, Hoos field and Little Hoos field, lie slightly to the north-west of the mansion house. The experimental area is thus limited to a small range of six fields, with a total area of about 37 acres. In choosing his areas for experiments, Sir John Lawes did not worry much about the disintegration of the estate which resulted when he donated these experimental plots to the Trust. But he emphasised clearly the absolute necessity for uniformity of soil, a point which is of the greatest importance when one is planning experimental work, and one which should not be lost sight of in India, even if, to obtain it, one must give the experimental area a rather patchwork appearance. Another point which will be of interest to Indian readers is the description of the Rothamsted soils. Writing of it in 1847 Lawes said: "The soil upon which my experiments were tried consists of rather a heavy loam, resting upon chalk, capable of producing good wheat when well manured." Mr. Hall remarks that it is fairly uniform in the different fields and consists essentially of a heavy loam containing little coarse sand or grit, but a considerable amount of fine sand and silt and a large body of clay. In consequence the soil has to be worked with care, and if tilled when wet it dries into impracticable clods. It "runs together" if heavy rain falls after a tilth has been established and then dries with a hard unkindly surface, these difficulties being much exaggerated on the plots which have been farmed for a long time without any supply of organic matter in the manures.

Mr. Hall might be writing of many parts of India. To how many of us are lands such as he describes an absolute

heart-break? But it is encouraging to learn that the addition of organic manures helps to bring the land into good condition and with farmyard and green manuring we can manage this in most parts of India.

The ordinary meteorological observations are taken with great accuracy at Rothamsted. I should not mention them here were it not that any one who visits Nawabganj, near Cawnpore, can see a copy there of the appliances used at Rothamsted for measuring the amount of water percolating through bare soil. Briefly described, these experiments are carried out by means of drain-gauges,* with an area of 1/1000th of an acre. The soil is undermined at different depths—20, 40 and 60 inches, and the soil thus sectioned off is supported by perforated iron plates. Trenches are then cut round these sections of soil and the sections are isolated by brick or cement walls. The external soil is put back. The water percolates through the sectional block into zinc funnels from which it passes to the measuring cylinders.

The general impression at Cawnpore was that, experiments of this kind need hardly be undertaken generally in India; but the Cawnpore series will give an idea of what is done at Rothamsted.

Of the six experimental fields belonging to the Lawes Agricultural Trust, some have greater interest than others for an Indian agriculturist. For instance, the rotation experiments of the Agdell fields, being based on crops like swedes and clover, which are practically unknown in India, give no direct results that would appeal to agriculturists out here. But the scheme of the experiments may give helpful suggestions. The order of the rotation is :—

1st year : Swedes.
2nd year : Barley.
3rd year : Clover (or beans) or fallow.
4th year : Wheat.

* An illustrated description of such gauges will be found in the Memoirs of the Dept. Chem. Series, Vol. I, No. 4.

As regards manuring the scheme is :—

1. No manure.
2. Mineral manure only (*i.e.*, without nitrogen).
3. A complete manure.

The manures are applied only to the first crop of the rotation —the swedes—the remaining crops of the rotation getting the residual value of the manures only. These experiments began in 1848.

Without examining all the details of this scheme there are one or two obvious points which suggest themselves as of interest. What, in this system of continuous cropping, will be the effect of no manures on the various crops of the rotation, and what is the effect on the succeeding crops of the rotation by the introduction in the 3rd year of a leguminous crop—clover or beans—instead of a bare fallow?

With regard to the first point, the only crop that is not seriously affected is the deep-rooted wheat crop. In the 56th year, without any manure, it yielded no less than 19·6 bushels per acre. Swedes, practically surface feeders, do worst of all and clover and barley are small crops also. In the second course, *i.e.*, mineral manures without nitrogen—the crops of the rotation do just about as well as they do on the unmanured plot; but the clover—which is leguminous and fixes its own nitrogen—produces almost as much as on the fully manured field, yielding in the latter case 37·8 cwt. of hay as against 35·5 cwt. when a mineral manure without nitrogen is applied.

The effect of the leguminous crops is all in favour of clover: but the obvious fact is also clearly emphasised that the benefit from a leguminous crop on a subsequent crop depends greatly on the vitality and quality of the leguminous crop. On the unmanured plots where the clover crop averages only 15·2 cwt., there is a loss in wheat in comparison with a crop following bare fallow of 16·7 per cent. This is doubtless because on the unmanured plot the growth of clover is too small to leave behind any residue of nitrogen. It is also noted that after a good crop of clover the beneficial effect is obvious throughout the whole rotation.

On the contrary, the introduction of beans into the rotation seems to confer no benefit at all. In every case, wheat following beans shows a percentage of decrease in comparison with the outturn after a bare fallow. This is probably due to the habit of the bean crop, though it also indicates that the question of the exact effect of the different legumes on soils is still an undecided one.

From Agdell we pass into Barn field, but the crop here is Mangel Wurzel—a crop that does not interest India much, though a great fodder staple in the south of England. So we may pass the elaborate manurial experiments on this crop and move on to the Park, close to the mansion house of Rothamsted, a block of some seven acres which contains probably the most remarkable series of experiments on grass in Great Britain.

The series of experiments started in 1856, but the Park has been under grass from time immemorial. There is no record of any seed having ever been sown: but when the experiments commenced, the herbage was fairly uniform.

The Park has been divided into 20 sections, to which an elaborate system of manuring has been applied. The produce of these plots is separately weighed whenever it is cut for hay—usually twice a year—and a botanical analysis is also made to ascertain the effects of the different manures on the composition of the herbage.

The results may be summarised briefly as follows:—

On the unmanured plots there is no sign of exhaustion as determined by the yield, but a rankness of the herbage is apparent. The proportion of weeds increases every year and now amounts to almost half the herbage. Quaking grass is about 20 per cent. of the herbage and Sheep's Fescue, Bird's Foot Trefoil, Burnet Hawk Bit and Black Knapweed, are very common.

When nitrogenous manures alone are used, it has been found that nitrate of soda is the best manure to use as it encourages the growth of deep-rooted grasses, like Meadow Foxtail, etc. Ammonium salts, used alone, were found to cause sourness in the

land while nitrate of soda produced a more varied herbage than ammonium salts.

In the case of mineral manures used alone, when a complete mineral manure was applied, plots showed no signs of declining fertility. Nitrogen seemed to be supplied by the leguminous weeds which formed 24 per cent. of the herbage. The predominant legume was *Lathyrus pracensis*, red and white clover were also present together with a large number of grasses and, amongst the weeds, Yarrow and Sorrel are abundant.

When potash is omitted, the plots show poor results and there is a great poverty of leguminous herbage—there being only about half as much as on the plot getting a complete mineral manure. The characteristic legume under this treatment is Bird's Foot Trefoil and the characteristic weeds are the Butter Cup, Black Knapweed Plantain and Yarrow.

When superphosphate alone is applied, the result is a very impoverished appearance and an outturn little more than that from unmanured plots. Quaking grass predominates and, amongst the weeds, Hawk Bit Burnet and Plantain. The presence of these weeds and inferior grasses seems to indicate that these plots are more exhausted than the unmanured ones. The results show the disastrous effects of long-continued one-sided manuring.

The final group is the application of complete manures—minerals plus nitrogen. In the application of these, the quantities of the mineral manures and their relative ratios remain the same on all plots, but the quantities of nitrogen vary from plot to plot.

The heaviest yield of all the plots was obtained from a complete mineral manure, containing both phosphoric acid and potash, plus 129 lbs. of ammonium salts to the acre. But, while greatest in quantity, excessive use of nitrogenous manures on this plot causes the herbage to become very coarse; consisting as it did, of Coarse Meadow Foxtail, Yorkshire Fog and Tall Oat Grass. The soil of this plot has also become sour and unhealthy and leguminous herbage has been killed out. The results seem to prove that nitrate of soda in combination with minerals acts

better than ammonium sulphate. They also show that mineral manuring always increases the leguminous herbage. The best result of all the plots is probably obtained from a plot which receives a complete mineral manure, plus nitrate of soda 43 lbs. of nitrogen per acre. This quantity probably marks the limit of profitable manuring with nitrate of soda.

It may safely be said, without fear of contradiction, that the Broadbalk field on which the wheat experiments are carried out is the most famous experimental plot in the world. Here, since 1843, experiments on the continuous growth of wheat have been carried out, and, since 1852 the scheme of manurial treatment has been constant. But in this series, the particular plot that stands out conspicuously is the unmanured plot which, laid down in 1843, and having been previously unmanured for four years—now in its 70th year of continuous wheat cultivation—has given for the last four years an average outturn of some 12½ to 13 bushels per acre, which is the average output of the wheat area of the world. There have been fluctuations, *e.g.*, in 1906 the plot yielded at the rate of 18 bushels per acre; but these fluctuations have always been attributable to the condition of the seasons. So far as can be judged, there is no indication of a likely decrease in outturn, and the reason for this apparently constant return is a question, which, while of extreme scientific interest, has not yet been satisfactorily explained.

The other plots are treated with farmyard manure, minerals, single, double and treble ammonium salts, plus minerals, single nitrate and mineral, rape cake and so on. To discuss the results in detail would be outside the province of this article so that only a brief outline will be given. In the plot which received farmyard manure calculated to supply, on an average, 200 lbs. of nitrogen, 78 lbs. of phosphoric acid, and 235 lbs. of potash, a rapid rise in fertility was noticeable for the first years, due to the original exhaustion of the land. This was followed by a decline during the decade, 1872-81, but since then the yield of grain has again rapidly risen. Of the reserves left on the plot, it has been calculated from other experiments at Rothamsted

that, even in fifty years, it will be impossible to crop them out. In the plots which received artificial manures which supply nitrogen, potash and phosphoric acid without the addition of any organic matter to form humus, the plot which received double ammonium salts and minerals came very near in yield to the farmyard manure plot and as yet shows no decline in fertility. In the plot which received single ammonium salts and minerals the supply of nitrogen proved insufficient and a decline of fertility is evident for a time, although, as in the case of the unmanured plot, a fairly constant yield for subsequent years has been got. In the plot which received nitrogen only in the shape of an annual dressing of 400 lbs. of ammonium salts the crop yields were well maintained, but the crops present an unhealthy appearance, were slow to mature, and liable to rust.

The important conclusion to be drawn from the experiments is that wheat, with judicious manuring, although grown year after year in the same land, can be made to produce as paying crops as when grown in rotation in the ordinary way.

One of the most interesting results of these continuous wheat experiments is the determination of the fate of the principal manurial constituents. Of about 10,000 lbs. of nitrogen supplied as dung during the whole period only about 2,600 lbs. have been recovered in the crop (about 26%) and of the remainder, after analysis of the soil, 5,670 lbs. cannot be accounted for. It has probably been washed away as nitrate into the drains or converted into free nitrogen gas by bacterial action. In connection with phosphoric acid and potash it is interesting to note that Dr. Dyer's analysis shows that of the surplus one ought to expect, after deduction of the amounts taken off by the crops, the greater part of this excess was found in the top 9 inches of the soil, and in a form readily available for plant food. These results have been of far-reaching importance as contribution towards general agricultural theory.

In the Hoos field we have a number of experiments. The principal series is that on the continuous growth of barley. This crop is only of importance in the north of India, so that it is

not important to give a detailed account of the various results. But it may be remarked that, so far as gross outturn is concerned, the best results would appear to be obtained from farmyard manure at the rate of 14 tons to the acre. Results also show that the decline in production on land continuously cultivated with barley and without any manure is much more rapid than in the case of continuous wheat.

In this field an attempt has also been made to grow leguminous crops continuously since 1848. Despite various schemes of manuring, the crops as a rule have been very small, and in some cases have failed completely. In 1898 a portion of these plots was ploughed up and 5 crops of wheat taken off without manure to test the amount of nitrogen accumulated by the leguminous crops and left in the soil. Various experiments of a similar kind with leguminous crops are still being carried on in this field, a halt in the old series having been called in 1903, by fallowing to clear the land and the new series originating with 1904.

In this field there is also an interesting series of experiments on the residual value of manures. For 26 years potatoes were grown on various plots with different manures. It may incidentally be remarked that, from the outturns, Rothamsted compares badly, as potato land, with the west coast of Ayrshire or the Lothians, 5 tons per acre being apparently the best it can do under any form of manuring. In 1902 no manure was applied and barley was sown in that year and in 1903, and Black Tartarian Oats in 1904. The experiment shows that the residue is very rapidly exhausted; for instance, when farmyard manure at the rate of 14 tons per acre had been applied to the potato crop from 1883 to 1901 with a previous manuring of superphosphate from 1876 to 1883, the average produce of total tubers per acre during that period (1876 to 1901 inclusive) was 4·8 tons. In 1902, when a barley crop was taken without any manure, the yield was 71 bushels of dressed grain and 5,216 lbs. of straw, and when this was followed by a second barley crop without manure in 1903, the yield declined to 46·9 bushels of dressed

grain and 3,474 lbs. of straw. A subsequent crop of oats in 1904, again without manure, yielded 55·5 bushels of grain and 3,060 lbs. of straw. In 1906 barley had fallen to 36 bushels per acre. The rapid decline in barley is striking, but the series of experiments hardly as yet admits of accurate deductions.

At Rothamsted, as at most experimental stations, trials have been made with the various media for inoculating leguminous crops. The crops subjected to the various processes are red clover and the cow-pea (*Vigna catiang*), and the method of the experiment is as follows: In one plot the soil is inoculated with Hiltner's preparation; in the second Moore's preparation is applied. The third plot contains soil from a field which had carried red clover in 1904, and the fourth plot is left uninoculated. No definite conclusions had been reached when I visited Rothamsted, but the mean of the first two crops indicates the slight superiority of Hiltner's preparation over the other inoculations, while all show an advantage over the uninoculated plot.

Another interesting series of experiments in this field is the effect of bare fallow on wheat, a comparison being instituted with the continuous unmatured wheat plot in the Broadbalk field. In this way it is possible to deduce the value of the bare fallow which over a period of 56 years has been very marked in favour of wheat after fallow.

The last experimental plot on the estate is the Little Hoos field and, in many ways, it is not the least interesting of the series. The principle underlying the experiments in this field is the testing of the residual value of certain typical manures, *i.e.*, the value of the residues left in the soil after one or more crops have been grown since the time of their application. To eliminate the effect of season, the result yielded by the residue is, in all cases, compared with that of a new application of the same manure, as well as with a continuously unmanured check plot. The experiment is on a four years' rotation of swedes, barley, mangels and oats and the residual value of the manures is tested thus up to the fourth year after application. In many respects, this is one of the most interesting series of experiments at

Rothamsted and has an economic bearing on the valuation of improvements to land when arbitration questions arise.

The impression which must be left on the mind after a consideration of the work that is being done at Rothamsted is the largeness of conception, which framed these lines of investigation. "Continuity" is the keynote of the work at Rothamsted. It was illustrated in the long association of Lawes and Gilbert: it is the principle running through all the experiments. There was something grand in the conception of the lines of work; a confidence that defied the limitations of nature and that was inspired with an intuitional assurance that lines of research were being originated which other workers would continue and posterity would not willingly let die. Their outlook was large; they worked not for the present that was with them but for the future that was to be. The result has been a series of experiments which is quite unique in the history of scientific agriculture and which might well by this time adopt the mantle of hoary-headed age. But it is a robust and vigorous old age. There are no traces of senile decay.

(To be continued.)

EXPERIMENTAL WORK ON FIBRES IN INDIA

By R. S. FINLOW, B.SC., F.C.S.,

Fibre Expert to the Government of Eastern Bengal and Assam.

THE work of the past year under this heading includes :—

Lines of work in 1907-08.

(*a*) Jute experiments carried out by the Agricultural Departments of Bengal and Eastern Bengal and Assam, with the object of improving the crop both as regards the yield and quality of fibre.

(*b*) Experimental trials in other Provinces of India in pursuance of the scheme to extend the cultivation of jute outside Bengal and Assam.

(*c*) An investigation into the deterioration of baled jute by the Fibre Expert to the Government of Eastern Bengal and Assam in collaboration with Messrs. Cross and Bevan, of London.

(*d*) Continuation of experimental work with flax and other fibres.

(*e*) The report of a Sub-Committee of the Board of Agriculture on the cultivation of fibre plants in India and the probable effect of extending such cultivation.

Bengal. Experiments with jute. Burdwan.

The jute experiments conducted by the Bengal Agricultural Department at the Burdwan Farm since 1904 are now regarded as having definitely proved, for the Burdwan District, that

(1) Farmyard manure (70 maunds) or castor cake ($7\frac{1}{2}$ maunds) per acre are the best and most economical manures.

(2) The crop should be sown about the third week in April on a thoroughly prepared seed bed.

(3) The plants should be thinned out to 4 inches apart.

(4) The yield of fibre increases with the age of the crop: but the stage at which the heaviest yield of fibre of the best quality is obtained is when the fruits have fully set.

(5) Any one of ten races of jute recommended may be grown.

A series of quantitative experiments have been carried out, showing the profitable nature of a rotation of jute and paddy or of jute and potatoes (the latter crop irrigated).

Cuttack.

The results of experiments at Cuttack have proved that jute grows well in parts of the Orissa Division, in rotation with paddy or potatoes if proper attention is paid to the manuring of the crop.

Experiments by the Eastern Bengal Department.

In collaboration with the Reporter on Economic Products to the Government of India, an extensive study is being made of the races of jute in Bengal and Eastern Bengal. A tentative account of the conclusions so far arrived at is contained in Agricultural Ledger No. 6 of 1907. So far it has been found possible to reduce the number of so-called races of *C. capsularis* from over one hundred to thirty-three, and of this residue there are many which are only being kept apart pending further observation. The tendency is, in fact, for the races to classify themselves under four main heads, *viz.*:—

Red stemmed	races which mature	early.
Do.	do.	late.
Green stemmed	do.	early.
Do.	do.	late.

Chemical and microscopical examination of the fibres.

A partial chemical and microscopical examination of the respective fibres of the various races shows great similarity in their composition and structure, thus supporting the field observations. There is, nevertheless, no doubt that the distinctions as regards quality—largely geographical—recognised in the jute tracts are genuine and, in view of this, a series of experiments has been devised to ascertain the effect of soil, climate and especially of the retting water on the quality of fibre produced.

Effect of soil, climate and retting water on quality of fibre.

As a result of preliminary selection, one or two races are now regarded as pure, and cross-fertilisation experiments have been commenced this season (1908). It remains for time to show whether any great improvement will be brought about by this means. In view of the comparatively slight differences which exist between the various races, it is hardly to be expected that such advantages will accrue in the case of jute as have been brought about by cross-fertilisation work with other crops. The experiments will, however, in any case, render clear many points which are now obscure.

Cross-breeding experiments.

With the object of inducing the *ryots* in the Chittagong District to grow jute as a field crop for export, instead of on a garden scale for home use, a special grant of money was made by the Government of Eastern Bengal and Assam for a series of demonstrations in three typical tracts. The demonstrations which have been carried out by cultivators from Dacca and, as far as possible, without direct departmental interference are, in one sense, an experiment to ascertain whether proved results can be brought to the *ryot's* notice in an informal way through the agency of men of his own class.

Demonstration of jute cultivation in Chittagong.

Experiments with the object of introducing jute cultivation continue to be made in—

Jute experiments in other Provinces.

(*a*) The Bombay Presidency,
(*b*) The Central Provinces,
(*c*) The Madras Presidency, and
(*d*) The Punjab.

At Ganeshkhind, near Poona, progress was made last season (1907), in that one plot yielded a profit for the first time, after deducting all expenses. This year's crop (1908) is still more hopeful, especially as experience in dealing with it is enabling cultivation expenses to be reduced.

Bombay.

Trials in 1907 at Nagpur and Raipur under irrigation were successful. The yield at Nagpur was at the rate of $18\frac{1}{4}$ mds. per acre and the fibre was valued at Rs. 6 per md., representing a gross return of Rs. 112

Central Provinces.

per acre. Jute was sown on two demonstration farms this year; but the crops have been adversely affected by the unfavourable weather in the early part of the season. Nevertheless, a very fine crop has been grown at Telinkheri near Nagpur, the yield of which is estimated at over 20 mds. per acre. It is now recognised by the Central Provinces Agricultural Department that jute is capable of becoming a useful rotation crop in the Provinces, and steps are being taken to bring facts connected with successful cultivation to the notice of the *ryot*.

Madras.

Trials are being continued this year (1908) in the Godaveri and Cauveri Deltas and on the Malabar Coast. At Tanjore in the Cauveri Delta, the plots are not so good as on the Malabar Coast where the climate is not unlike that of Bengal and where one crop grew 9 feet high in two months. Seed for over 20 acres was sent for experimental cultivation to Madras this season, and the Agricultural Department is making an attempt to create a local market for the fibre produced.

Punjab.

Owing to a severe attack of caterpillars, the plots at Lyallpur this year are not the success they were in 1907 when an average yield of 11 mds. of fibre per acre was obtained, the return from some of the plots being much higher. The cultivators in the Chenab Colony are very enterprising, but their wheat and oilseed crops which they grow chiefly for export are very profitable in average years, and it is doubtful whether Jute cultivation will be taken up seriously in the Colony or any part of the Punjab. In the event of an extension of such cultivation, special tanks filled with water from the canal system would be necessary for retting. These tanks could be cheaply constructed, but for general cultivation and for preparation for market the cost of labour would be excessive as compared with other parts of India.

Burma

At present Jute is only grown by the jails where the fibre is made up into bags and rough mats; but experiments are in progress in some districts where it is anticipated the crop may thrive. The lack of suffi-

cient labour is likely to be a serious difficulty in the way of development.

Distribution of seed.

The Agricultural Departments of Bengal and Eastern Bengal are both engaged in the production and distribution of good jute seed of guaranteed quality.

The deterioration of baled jute.

After baling, some jute undergoes, sometimes in the course of a few weeks, a deterioration known as "heart damage," whereby the whole nature of the fibre is changed. The chief characteristic of the deterioration is an entire loss of tensile strength, the fibre becoming so brittle as to be capable of being rubbed into a fine powder. Three per cent. of the imports into Dundee in 1906 are said to have been rejected on account of "heart damage." The Agricultural Department in Eastern Bengal and Assam arranged to collaborate with Messrs. Cross and Bevan, of London, who afterwards obtained a grant of money from the Secretary of State for India, in an investigation into the causes and possible means of prevention of the deterioration. Messrs. Cross and Bevan have presented a report to the India Office, based on the results of their examination of a number of bales of jute, specially treated in India, by the Eastern Bengal Department before export to London. The jute in all the bales was watered and the contents of some bales were treated with antiseptics, but in no case was there, on arrival, any sign of "heart damage." The presence of nearly 30 per cent. of water in the baled fibre, which was of first class quality, did not cause evident damage to the bales which were sent as an experiment. Bacteriological examination of the contents of the bales showed that the fibre treated with antiseptics (formalin and corrosive sublimate) was nearly sterile on arrival, and Messrs. Cross and Bevan draw the conclusion that the presence of formalin would prevent the occurrence of "heart damage." Although this conjecture may possibly be correct, it still remains to be proved; it is hardly a justifiable deduction, from the evidence available. Meanwhile, in experiments at Pusa, "heart damage" has been produced under well-defined conditions,

and it is hoped that definite results will be obtained in the near future from the work in India.

Flax in Behar.

Experiments with this crop in Behar have made considerable progress. During the cold weather of 1907, a large area (over 100 acres) was grown at Dooriah under the supervision of Mr. Vanderkerkhove, a practical Flax Farmer from Belgium, engaged by the Government of Bengal. Mr. Vanderkerkhove also gave advice on the experimental cultivation of this crop at Pusa. The results obtained are very satisfactory, the straw produced being far better, both in quantity and quality, than in the previous year. The experiments indicate that in an ordinary season in Behar, flax is likely to yield a handsome profit, which is estimated at Rs. 74 per acre. Mr. Vanderkerkhove has issued a report, an exhaustive summary of which, by the Inspector-General of Agriculture, appeared in the *Agricultural Journal of India*, Vol. III, Part 2, April 1907. Mr. Vanderkerkhove has been engaged for a further term of five years in order that he may assist in the thorough working out of questions germane to the new industry, such as the comparison of indigenous and exotic varieties of flax, the selection of proper lands, manures, rotations and retting methods.

Flax in Eastern Bengal and Assam.

Experimental cultivation of flax last season (1907) at Dacca and in Cachar produced sufficiently good results to warrant extended trials, which were arranged for this year in Assam. Other conditions being equal, the absence of lime in the retting water would probably enable Assam to produce a higher grade of fibre than Behar. An illustrated Bulletin, dealing specially with the prospects of flax in Eastern Bengal and Assam, is about to be issued.

Bombay and Kashmir.

Arrangements have also been made for experiments with flax this season in Bombay and in Kashmir.

Other fibre plants.

A general investigation of Indian fibre-yielding plants has been commenced, and is being carried out not only with regard to the intrinsic value of the fibre of each, but with reference also to the agricultural

possibilities of those plants which are usually cultivated or which grow naturally in forests or on waste or other places.

REPORT OF THE SUB-COMMITTEE OF THE BOARD OF AGRICULTURE.

This Committee arrived at the following conclusions :—

(*a*) That a large and profitable extension of jute cultivation is possible and probable in Assam, and that owing to the fact that the cultivation of jute does not prevent the raising of paddy or rabi food crop in the same year, such an extension would not menace the food-supply of the cultivators.

(*b*) That experimental trials have justified the belief that jute may be profitably cultivated in parts of the Central Provinces, Bombay and Madras.

(*c*) That difficulties regarding retting water in the Punjab and labour in Burma will probably militate against successful jute cultivation in these Provinces.

(*d*) That a considerable and advantageous extension of Sann-hemp cultivation might take place in the Central Provinces and in Madras, and that the growing of ***Hibiscus cannabinus*** (a jute substitute) might be encouraged in tracts whose climatic conditions are not suitable for jute.

(*e*) That extensive trials have proved the possibility of a successful flax industry in Behar and that the prospects of extending the cultivation of this fibre crop to other tracts should be investigated.

(*f*) That a considerable increase of Agave cultivation by capitalists is possible in Assam; but that the chances of its success in drier climates still remain to be proved.

(*g*) Rhea has failed in Behar, which is too dry, and its successful cultivation is likely to be limited to a comparatively narrow zone, where both climate and soil are particularly suitable. Neither agave nor rhea are likely to be taken up on a large scale by cultivators in the near future.

(*h*) Bearing in mind the importance of not allowing non-food crops to encroach on the area necessary for the food supply, fibre

crops which only occupy the land for one season are generally to be preferred to those of a perennial nature.

(*i*) That no such diminution of prices is likely as would render the cultivation of fibre crops unprofitable.

SOME INDIRECT BENEFITS OF IRRIGATION NOT GENERALLY RECOGNIZED.

BY HENRY MARSH, C.I.E., M INST.C.E.,

Consulting Engineer, Protective Irrigation Works, Central India.

MANY people think that Irrigation from canals, wells, and tanks is only of use as a protective agent in tracts of precarious or slight rainfall. They know, of course, that millions of acres have been reclaimed from desert by the harnessing of rivers in the Punjab, in Sindh, and in Egypt. But they are probably not aware of the many indirect benefits which accrue to the State and agriculture from the presence of unfailing irrigation even when the rainfall is fair to good. In this article it is proposed to deal with the advantages which are thus derived, and though not patent to the public, are well known to revenue officers in Upper India.

2. Before going into details, it is well to summarise these unconsidered assets as follows :—

(*a*) Power of substituting immediate sowings in case of destruction to advanced crops, or harvests.

(*b*) Diversity of cropping, *i.e.*, insurance against losses.

(*c*) Maintenance of cultivation, and demand for labour throughout the season.

(*d*) Presence of fodder, pasturage, and water for cattle.

(*e*) Improved sanitary conditions.

(*f*) General increase of comfort, well-being, and decrease of crime.

Power of substituting new sowings in case of accidents to advanced crops or harvests.

3. The last two decades have afforded many melancholy opportunities of observing injuries to crops, which were giving splendid promise of bumper harvests. In 1904-05 the autumn sowings had been unusually extensive, and the winter rains had benefited

them to such an extent that prospects were exceptionally good. However, three or four days of extraordinary frost in the beginning of February 1905 completely changed these happy conditions. All advanced crops were utterly ruined, and where the peasants had no irrigation to water the fields, their plight was very serious. They simply had nothing to look forward to, until the following monsoon would enable them to sow kharif grains. In Bundelkund the rain did not come at all, and thus misfortune followed misfortune. The case was, however, very different with the irrigating tenants. The ruined wheat fields were quickly ploughed into the soil, and sown with "zaid" crops, *i.e.*, "chelma" (*Panicum miliaceum*), vegetables, melons, etc. The cultivation of "chelma" proved to be a very sound enterprise, as it ripened in two months, and produced five or six maunds of grain to the acre. Other tenants got the land ready for sugar, if they had the necessary manure. Others prepared it for April sowings of maize, juar, cotton, and hot weather rice. Maize sown at this period produced cobs in July, and fetched ready money in the local markets. Early cotton plants were well advanced, when the monsoon arrived, and were therefore not liable to injury from flooding. This form of cultivation is largely replacing the indigo of the Jumna and Ganges Canals, and requires every encouragement. It enriches the land and produces a better class of fibre. Irrigation was also the cause of other benefits in this phenomenal frost calamity of February 1905. Fields that had recently taken water escaped almost entirely. I was Chief Engineer of Irrigation at the time in the United Provinces, and remember well having to run the Canals, although the executive staff wished to have them closed for urgent repairs. The water thus given had a most beneficial effect in resuscitating crops that were seemingly killed by the excessively low temperature. After a short period of, so to speak, hibernation, they recovered, and gave very fair returns. In Muzaffarnagar and Saharanpore, where frost is a common occurrence, the cultivators are constantly on the look-out for it in the winter months, and freely irrigate the young crops to prevent mischief. They attribute the protection to the

thicker and stronger growth of the irrigated plant. This idea is similar to that held by cultivators of unirrigated soils. They rejoice exceedingly when propitious rains arrive before the frosty season. Experience proves that the young rabi is much strengthened by the damp, and thus able to resist subsequent low temperatures. So far I have only dealt with the case of the calamitous frost in 1905, and have shown that the irrigating tenant was in a position to retrieve his losses by fresh sowings. But the same reasoning applies to other agricultural disasters. Hardly a year passes, in which the Gazettes do not record the devastating effects in some parts of the country from locusts, hail or rust. In the report on the famine of 1895-96-97, it is recorded that the drought of these years merely completed the agricultural ruin, caused by the excessive winter rains in 1892-93-94 In the last-named seasons immense sheets of spring crops were destroyed by blight. Lowlying lands were too wet for cultivation. Even where the wheat and barley had ripened, and had been cut, the unseasonable rain and storms damaged the grain on the threshing floors. Independent of these well-known calamities, cultivators of tracts near forests or jungles frequently find their fields eaten up in one night by a herd of Nilgai or Deer. Here, again, the case of the owners is black indeed, if they have no means of resowing crops, until the following monsoon. I have recounted all these calamities, to show how many trials beset a cultivator, and how speculative are his chances of harvest profits, unless he has the means of renewing his sowings without delay.

Insuring advantages of irrigation (*i.e.*, diversity of cropping).

4. All wise agriculturists agree in the advantage of cultivating a variety of crops, *i.e.*, "in not carrying all the eggs in one basket." The Indian peasant follows out this idea in a rough way, by sowing various mixtures, which is not always the best form of insurance, as it depreciates the market price of his grain. Thus, rice and *kodo*, gram and wheat, peas and barley are cultivated at the same time, and in the same field. There are many other combinations, but the main idea is, that dry weather will

suit one plant, and a rainy season the second : hence some measure of success may be expected. Where irrigation exists, the position of the cultivator is much sounder. Continuous and heavy rain, which is disastrous to cotton, millets, and cold weather cereals is advantageous to sugarcane and rice. Without irrigation these valuable crops are rarely attempted, except in low-lying lands. This form of insurance is very sound, and is proved by the fact, that remissions are almost unknown, where sugar-cane and rice are cultivated and irrigated. They flourish mostly in damp, cool climates, but require water to mature them. Contrary to general opinion, it is in these climates that Irrigation Projects pay best. Proof may be given, by quoting the following extract from page 87 of the Sarda Canal Project of 1903.

"Hence the annual value of a cusec is much higher in the moist doabs of the Eastern Jumna Canal than in that of the drier and hotter country, watered by the Lower Ganges Canal. For the last five years they stand thus :

VALUE OF CUSECS.

	Eastern Jumna Canal.	Lower Ganges Canal.
	Rs.	Rs.
1898-99	... 1,172	... 571
1899-00	... 1,215	... 704
1900-01	... 1,029	... 558
1901-02	... 1,187	... 636
1902-03	... 1,232	... 705

It is also urged that the revenue will not develop as rapidly as is anticipated on account of the slow progress of the Agra Canal. Here, again, it may be pointed out that the great dryness of the country watered by the latter work has been a bar to the cultivation of first class crops."

Maintenance of cultivation, and demand for labour throughout the season.

5. These results of irrigation are very important, and are well understood by Collectors who have held charge of protected and unprotected districts. In the former, they know that agricultural operations never cease throughout the year : the labourers never have a slack time and are continually ploughing, sowing, weeding, reaping, or threshing. Crime is greatly reduced, and in seasons

of drought, the demand for labour is all the greater. Examining the operations of the year, we find that in January and February, the ground is being prepared for sugar sowings, whilst the matured cane is being harvested, and the juice expressed. The rabi crop requires great attention. Weeding, watering, fencing, and keeping off marauding animals occupy a number of hands. Harvesting of the rape or mustard is carried out in February; picking the plants and expressing the oil absorb a good deal of labour. In March and April the cutting, carrying, and threshing of the rabi is in full swing, and labourers are at a premium. Much difficulty is experienced in finding hands to hoe, and tend young sugar. Moreover, the fallow land has to be irrigated for maize, cotton, juar, or hot weather rice. In May the threshing out is still often incomplete, and the young irrigated crops require much attention. In June, July, August and September, if the monsoon is good, ploughing, sowing, and weeding occupy many people: early crops of maize and rice are cut and garnered. If on the other hand the monsoon is a failure, labour is in strong request to push on irrigation for sowing food crops, and for saving standing crops. October, November and December are absorbed in sowing the rabi, in irrigating it, and in completing the kharif harvest. Thus it is easy to see that in a well-protected country, labour is in demand throughout the year, peasants have little time to indulge in lawlessness, or in following out the freebooting instincts of their ancestors. For 31 years I served on the Ganges and Jumna Canal system: and though many famines and scarcities visited Upper India during that long period, I never saw a famine, and never saw famine labourers at work. Indeed, my great difficulty was to find hands to carry out the many sanctioned projects for new canal branches and drainage works. But during the short period in which I toured in Central India, I was brought face to face with grim starvation, and aimless wandering in two seasons out of three. This is strong testimony to the policy of pushing on protective works. It is surely better to spend money in constructing canals, tanks and wells, even though a productive return is not expected

than to await famine, distress, epidemics, etc., and spend large uneconomic sums in relieving them. In the latter case the outlay is often greater, the country is pauperized, officials are overworked, and seldom do we find any permanent result arising from all the harassing trouble and strain on State resources.

Presence of fodder, pasturage, and water for cattle.

6. Those who have experienced a severe drought can hardly have forgotten the terrible mortality amongst cattle. I have seen thousands of the weary emaciated beasts, driven along the Bombay road towards Malwa in 1905 and 1906. Rain seldom fails in that country, and hence it has earned a great reputation as a place of refuge in times of famine. Similarly, in 1899-1900, I have seen large herds driven from Rajputana and the Punjab to the Ganges khadir, and the Kumaun Terai. In all these disastrous trekkings, many losses were incurred, and bones of the wretched animals, lying along the roads, were silent witnesses to the fact. Independent of these casualties, wholesale butchering was practised in some localities. At Kunch in Jalaun, thousands were disposed of in this way. The owners sold them for a trifle, and the contractors made some profit from the skins and bones. The loss to the country must have been immense, and Government was obliged to advance large sums to the cultivators. Without this assistance, ploughing in the succeeding monsoon would have been seriously affected.

Where irrigation exists, all this horror is avoided. Water is of course plentiful, and so is the straw of all the cereal crops raised by the canals. The banks of the channels afford a certain amount of grazing, whilst spring level rises high in low lands, and causes a plentiful growth of herbage. This latter point is very important. In the valleys below tanks the grass is permanent and of great value. For miles below the embankments useful streams trickle along, and are a blessing to man and beast. The rise of spring level is also of immense use in rendering well-water accessible. This matter is, however, seldom realized until a tank embankment falls into disrepair, and the commanded wells become useless.

Improved Sanitary conditions.

7. Years ago it was thought that canal irrigation must be the cause of many forms of disease, to which natives and Europeans are liable, in a tropical climate. The belief bore good fruit in one way, as Government sanctioned large sums of money for the execution of drainage works. Remedial measures in the way of reduction of excessive watering were also carried out. More branches, and more distributaries were constructed, and this wise policy acted as an effectual safeguard against useless irrigation and water-logging. Cultivators who were accustomed to deluge their fields weekly are now fortunate if their turn comes once a fortnight, or once a month in times of low volume. This is all good for the land, and for themselves. Still, one famous Sanitary Commissioner was rabid on the subject, and pressed the Local Government of the North-Western Provinces not only to close up some canals, but to desist from further extensions. When the case was referred to the Secretary and Chief Engineer for irrigation, he pleaded that canal-irrigated villages would show a better return of health than those of unirrigated villages in the same latitude. He considered this would be the case, as the inhabitants of the former were better clothed and better fed. Investigation proved that the Chief Engineer was right, and the matter was allowed to drop. Very little argument is required to show that though fever may be caused by irrigation, the sanitary advantages far outweigh the disadvantages. Natives live largely on dairy products, and it is therefore necessary that milch cattle should have good drinking-water. Without canals, streams, or large tanks this essential does not exist. The conditions in which some beasts have to quench their thirst in offensive village ponds are no doubt a danger to the public. Milch cattle have power to pass off poisonous ingredients in their milk, and thus it is easy to conclude why many outbreaks of disease take place in drought-stricken tracts. A well-known case of this kind occurred in Gloucestershire some thirty years ago, when a number of people were invalided, by consuming the milk from a certain dairy farm. Subsequent investigation proved that the bullocks and heifers on

the land were sick, and dying, whilst the cows which produced the deleterious milk were thriving. This fact gave the clue, and it was then discovered, that for the sake of salt, the beasts had been licking a keg of poisonous paint which had been left in the meadows. The cows did not suffer, as they passed off the poison in the milk ; the other beasts sickened and died. Very possibly similar reasons produced the terrible scourges of cholera which used to rage in the Meerut and Agra Divisions, before canal irrigation was introduced. The memorial stones on the camping grounds, giving lists of officers and soldiers who died from the disease 40 and 50 years ago are strong proofs of this conclusion. Such epidemics seem to have quitted this highly irrigated part of the country, and it may be claimed that the immunity is due to the presence of the flowing water in the canals. Nothing is so deadly as a scarcity of potable water in a tropical country. It has been very truly said that more lives are lost in India from want of water than from want of food. There is another great advantage in the introduction of canal water from the large rivers. Wells in Muttra and Agra Districts, that used to be brackish, have now become sweet. This is a great joy to the people, who used to struggle for vessels of potable water at the few wells which were not bitter.

- General improvement of the people and country.

8. In this paragraph an attempt will be made to indicate the general benefits which arise from the improved conditions already explained. The cultivators who are well placed, as regards irrigation, gradually reach a stage of assured financial stability. Though they may not obtain heavy harvests in years of drought, and though some crops may be lost by reason of various calamities, yet a portion of sowings will come to maturity, and splendid prices will be realized. In this way, the tenant clears off all debts, builds a better house for himself, keeps better cattle, and finds no trouble in marrying off his children. Altogether a better state of well-being is arrived at. Rents come in regularly, and instead of the headmen felling the mango groves, new plantations are laid out, and new wells are sunk. The population increases, the waste

lands are reclaimed, and brought under the plough. In time, villages comprising a few huts will become quite large towns connected with centres of trade by roads or railways. The advantages derived by Government are most important. The land revenue becomes stable, and advances are not required to tide the tenants over bad seasons. The people who are dacoits and cattle lifters become respectable, law-abiding members of society. Instead of spending large sums in maintaining peace, the State has to consider schemes for roads, hospitals, and schools. The increased wealth of the people leads them to make long pilgrimages, and the facilities of travelling must exercise a strong educative effect. It has been said with considerable truth that after all a railway engine is the best school master. Railways themselves benefit enormously by the prosperity of the cultivators. The exports of produce increase by leaps and bounds, and returns do not fall off in irrigated tracts, as they do in unprotected countries. India is mainly an agricultural country: nothing is so necessary to her as the development of irrigation facilities, and prevention of the wasteful escape of river water to the seas. Not only do these protective works afford food and occupation for millions, but the climate itself is modified beneficially. Intense aridity is checked, and healthful dews are created, which assist in the growth of herbage and trees. The Monsoon rains descend on levelled fields covered with young crops, and the latter act as powerful agents in preventing denudation, and limiting excessive floods in the main rivers. Mr. Buchanan, Under Secretary of State for India, has evidently grasped the advantages of developing irrigation works, and has impressed them on the House of Commons in his recent Budget Speech. He said: "There is no sphere of work in which the Indian Government has been engaged, which is more satisfactory to contemplate than that of the railway and irrigation works." * * * * "I have given notice of a bill for renewing our power of borrowing money for railway, irrigation, and other general purposes, but I have not yet had the opportunity of introducing it. It is a measure, however, that will generally commend itself to the approbation of the House, and

from it we may expect very excellent results will ensue. Every one will recognize also, that there is no part of our work which reflects more credit on us than the admirable irrigation work, large and small, which has been carried out in recent years. It has been a help to our revenue, tending also to mitigate the condition of the poorest people in their distress. We intend to go on in the future in pursuit of that policy."

WELLS IN THE GANGETIC ALLUVIUM.

By W. H. MORELAND, C.I.E., I.C.S.,

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It is no exaggeration to say that the first condition of the prosperity of the greater part of the Gangetic alluvial plain lies in the existence of irrigation wells. Even in ordinary seasons, most of the winter crops in this plain require irrigation for their success, and in dry seasons water becomes an absolute necessity for the maintenance of the people on the land. The system of canals constructed by the Government is admittedly an enormous asset, but (to take a recent instance) during the famine year 1907-08, the area irrigated from wells was three times that which was irrigated from canals: and while the activities of the engineers have already almost exhausted the supply of water available in the rivers which serve the United Provinces, the scope for increasing the number of wells is to all appearance still almost unlimited. It may therefore be of interest to readers in other parts of India to have a short account of what these wells are, and what are their advantages and their limitations.

The alluvium consists of a long and relatively narrow plain sloping from north and west, and the uniform surface broken by the valleys which have been carved out by the rivers since the period when geological changes brought the surface of the main alluvium about the level of flowing water. The depth of the alluvium is known to exceed a thousand feet in the central portions and throughout this depth its composition is remarkably uniform, beds of clay and sand succeeding one another with little variety. In a formation of this kind, there is naturally a fairly uniform water-table, that is to say, that where a hole

is dug to a certain depth, water will begin to percolate into it. The depth to percolation-level is determined mainly by the distance from the river valleys to which reference has just been made, and though it varies from season to season with the amount of rainfall, it maintains its relative position with substantial regularity. Figure 1, which is adapted from a paper by Colonel Clibborn, a former Principal of the Roorkee Civil Engineering College, shows diagrammatically the position of the water-table between two of the rivers in the Muzaffarnagar District, and is a fair illustration of the position in the greater part of the alluvium.

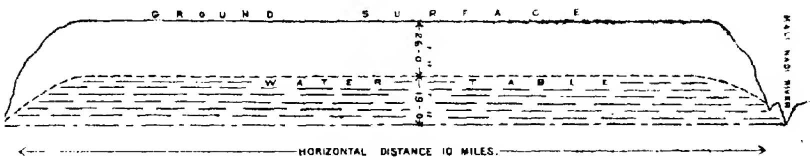


FIG. 1.—Position of Water Table.

In such country the simplest form of well is a hole dug down to a short distance below the percolation-level: this is a percolation well. The water will filter gradually into the hole, mainly from the bottom of the well, and can be drawn out by a bucket as it comes in. That even this crudest form of well is of important economic value may be inferred from the fact that something like a million of them were at work last winter in the United Provinces: their sole merit is their cheapness, since they do not in ordinary cases cost more than from 3 to 5 rupees, but cheapness is an important matter in a country where the possibilities of agriculture are limited by the scarcity of available capital. The defects of such wells are numerous, but the most important is the scantiness of their yield: it is rarely possible to work them by bullock-power, and as a rule the lift used is an earthen pot hung on a counterpoised lever and raised as it fills by manual labour. Those who use such wells have learned by experience that more haste means less speed, and the worker who appears to the onlooker to be wasting his time is in reality waiting for the moment when it will be safe to raise the lift.

The reason of this scanty supply is to be found in the fact that for any particular kind of sand or earth there is what has been well termed a *critical discharge*, that is to say, that from a unit of surface only a certain quantity of water can be safely drawn in unit time: if more than this quantity is taken from the well, the water enters it at an increased velocity, enough to set the sand moving: and once the sand at the bottom of the well is started moving, it will continue to move till the well is filled with sand nearly to percolation-level. If, therefore, a well is overtaxed by being made to yield a supply of water in excess of its critical discharge, the result is that the well is spoilt; and the men who use these wells have before anything else to make absolutely certain that they are not overtaxing the well, and must work slowly, no matter how pressing the need of water may be. Such wells therefore can yield only a discharge proportionate to the area of sand exposed at their bottom: and the cost and difficulty of construction increase so rapidly with an increase in diameter, that this simplest form of well can never give a large yield, and must remain what it is, essentially a poor man's well.

The suggestion will doubtless be made that the area of intake and therefore the supply, can be increased by increasing the depth of the well, and so obtaining a large surface of the sides below percolation-level. The objection to this course is that when water is drawn from the sides they rapidly fall in and render the well useless: when sand flows into a well from below, as has just been described, it has to be moved against the force of gravity, but the sand at the sides of the well has not to meet this resistance and has therefore a lower critical discharge and hence moves at a lower velocity than the sand at the bottom. Even with the wells carried a very short distance below percolation-level, it is usual to line the sides with brushwood to prevent their gradual disintegration, and after a short depth this precaution becomes insufficient and a more substantial lining is required. This problem, carrying percolation wells to a considerable depth, has not been worked out by the people, and its consideration must for the present be postponed.

But some unknown discoverer at some indefinite period hit on a method of making wells with an area of discharge independent of either the depth or the diameter, and where this method is available, its results are so superior that the question of improving percolation-wells becomes of little practical importance. This discoverer hit on the secret of making what are known in the alluvium as spring wells. The nature of these will become apparent from an examination of figure 2.

The ordinary spring well in the alluvium consists in essentials of a hole carried down below percolation-level to the first impervious layer of clay, which presumably overlies a layer of water-bearing sand. The layer of clay is then pierced by a smaller hole, and if the sand-bed below contains water in sufficient quantity, there is an immediate rush of water into the well until it rises approximately to the percolation-level. The initial rush of water is mixed with sand, but after a time, as water is drawn from the well, this admixture of sand ceases and pure water enters. How this happens is a question that was for long a puzzle; but it is now well ascertained that the effect of the first rush of sand is to leave a cavity immediately beneath the foundation-clay, and that this cavity goes on getting larger until its surface area is so great relatively to the velocity with which water enters the well that water passes from the sand to the cavity at less than the critical discharge of that particular form of sand. In a spring well, then, the actual size of the well has nothing to do with the yield: as the yield is increased, the cavity beneath the foundations is automatically enlarged, and but for one important consideration it might be possible to set to work and pump the whole sand-bed dry from a single well, with a diameter only sufficient to admit the pump.

The consideration in question is the effect of such an operation on the foundation-clay. Its tenacity is weakened by each enlargement of the cavity, and except where it is very thick, a time will come as the cavity enlarges when the tenacity of the clay will be overcome and it will fall in. The effect of this is practically to convert the spring well into a

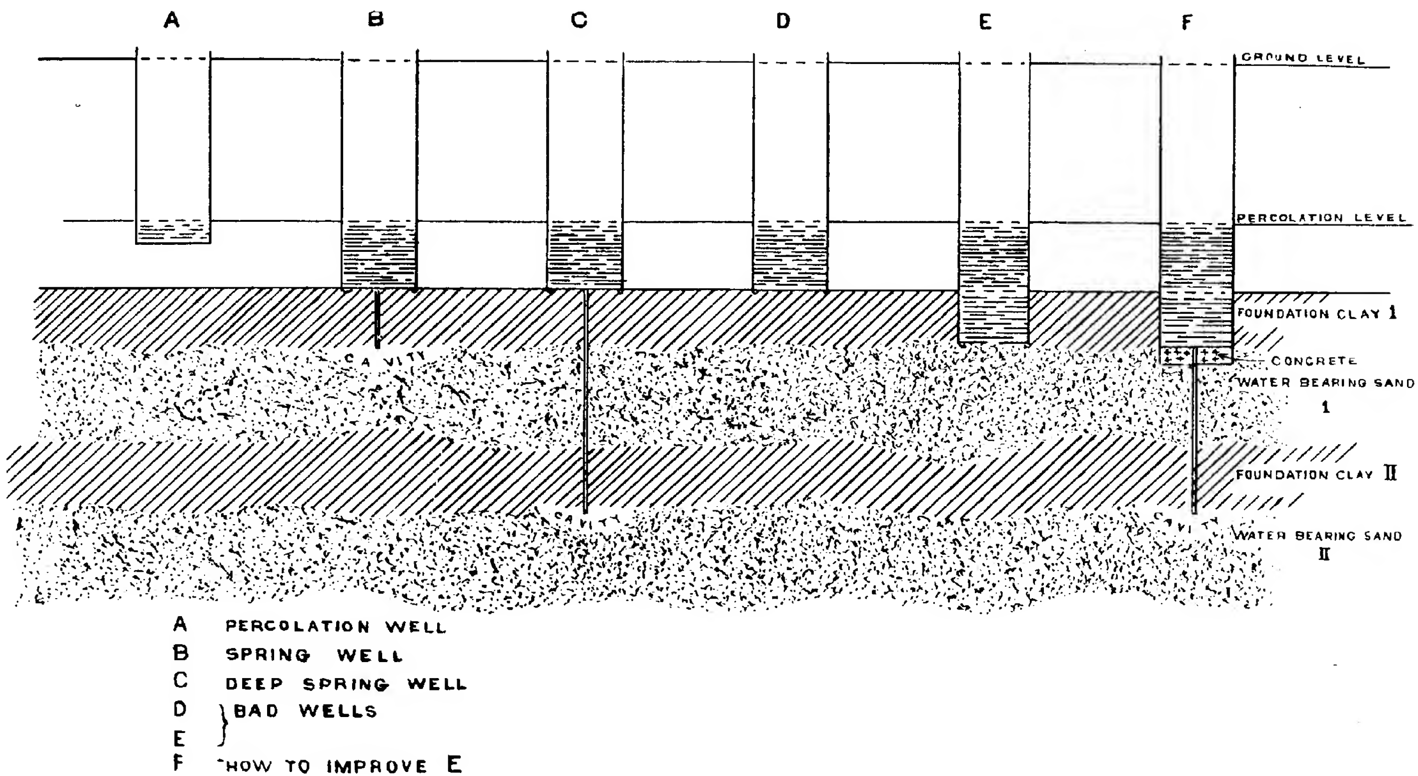


FIG. 2. Diagram showing various kinds of wells.

percolation-well of a very inefficient type, that is, practically to ruin the well.

Looking now at the diagram (fig. 2), the well A is the typical percolation well, a hole sunk a short distance below percolation-level: while B is the ordinary spring well sunk down to the first layer of clay below that level and then carried on by a narrow hole to the water-bearing sand below. These two types of wells are in practice familiar to all cultivators: they know that a spring well is best, that it requires a layer of impervious clay and that there is danger in overtaxing it beyond a certain limit, just as there is danger in overtaxing a percolation-well. In addition, they have accumulated an extraordinarily extensive mass of knowledge as to the positions where a foundation-clay can be found within a certain distance from the surface, so much so that in considerable areas of the United Provinces it is safe for a cultivator of the locality, but not for an outsider, to start sinking a well without a preliminary determination of the position and strength of the foundation-clay. But, on the other hand, there are also extensive areas where no such knowledge exists: sometimes there is an excellent foundation, but at a greater depth than has been adequately explored, while frequently the foundation is patchy, appearing in some places and thinning off close by, so that thrifty men dare not take the risk of failure and have to put up with inferior percolation-wells.

It must not, however, be supposed that even where a foundation-clay is available the well is an assured success: there is still the risk that the underlying sand may for one reason or another be inadequately supplied with water, a not uncommon phenomenon where the beds are shallow and of small extent. In most countries, it is sufficient before sinking a well to know that there is an adequate supply of water available, but in alluvium of this kind it is necessary to have information not only of the supply but of *the position and thickness of the layer of clay above it.* It is this characteristic which makes the various methods of water-finding practised elsewhere an inadequate preparation for the sinking of alluvial wells.

If now we suppose that the well B has been sunk as shown in the diagram and has failed to give a sufficient supply of water, the only remedy is to carry it down through the first sand-bed and the next layer of foundation-clay in order to tap the second layer of sand. The cultivator is ordinarily unable to do this as the expense of sinking a masonry cylinder to the second clay is prohibitive. But experience has shown that it is quite sufficient to sink an iron pipe about $2\frac{1}{2}$ inches in diameter from the bottom of the existing well down to the second layer of sand, and given proper tools, the cost of this operation is so much less than that of sinking the cylinder that it may be remunerative down to a depth of something like one hundred feet. We then get a well of the type shown as C in the diagram : the cylinder itself is deep enough to give a reservior of water in which the ordinary lifts will work, but the deeper part of the well consists simply of an iron pipe. The sinking of these pipes is not an important branch of the work of the Agricultural Department : tools and trained men being placed out where a demand exists, and it is quite remarkable how quickly a demand arises in a locality where a single well has been successfully dealt with. It is, of course, not always the case that the deeper layer of sand contains sufficient water, but experience has shown that, particularly on the eastern side of the Provinces, there is sufficient prospect of success to justify the operation in all cases where the well as it stands is inefficient.

The wells shown in the diagram as D and E are two ordinary types of inefficient wells. D shows the case where the layer of foundation-clay is too deep to be pierced by the primitive tools within the cultivator's reach. The well as it stands is an inefficient percolation-well, simply because the clay has not been pierced : in this case, the tools sent out by the Agricultural Department can correct the well at trifling expense as they can bore through almost any depth of clay. Such wells are occasionally made by cultivators who happen to light on an unusually deep layer of clay : the type E is, on the other hand, very rarely made by cultivators, but is not infrequently found where the well

has been built by a philanthropist, or by a contractor ignorant of the conditions. In E the cylinder has been carried through the foundation-clay and rests in the sand: it is an inefficient percolation-well, and very liable to subside if much water is drawn from it. The way to correct a well of this type is shown at F: as before a pipe is sunk through the next layer of clay to the deeper sand, and the bottom of the cylinder is then securely plugged with concrete round the pipe, so that no water whatever can enter from the upper sand: this precaution is necessary because if water is allowed to enter, there is still the risk of the sand below the cylinder moving and thus endangering its stability.

It will be gathered from this sketch of the most important forms of wells that there is considerable scope for assisting the public to make existing wells more efficient: but the organisation which has been developed serves equally to assist them by locating suitable sites for wells which it is proposed to make. The same tools which are used for sinking pipes serve for trial-borings to determine the position and thickness of the foundation-clay and the yield of water in the underlying sand: with their aid it becomes possible to make sure of the conditions before entering on what is for the people of the Province a very costly enterprise.

Still, with all possible improvements, wells in the alluvium have their limitations: each well has its maximum safe discharge and the penalty for overtaxing a well is usually its entire destruction. At the same time, it is true that many wells are worked at much less than the safe discharge, and there is a natural anxiety on the part of landholders to increase the yield by substituting power-pumps for the bullock-lift in ordinary use, the efficiency of which is limited both by the power of the cattle and by the diameter of the well. This anxiety gives rise to a very difficult problem, to determine the maximum safe discharge for a foundation-clay of given thickness and consistency: it is obvious that the large pumping-plants adapted for use on rivers and reservoirs would very soon wreck any alluvial well on which they might be installed, while small plants are relatively more expensive to

instal and less efficient to work. If, then, capital is to be invested in pumping machinery, it is obviously necessary for financial success to secure as nearly as possible the maximum safe discharge: and if the maximum is exceeded by even a small amount, the result is the destruction of the well. This problem has not yet been solved, and for the present it is necessary to advise landholders to go very cautiously in the matter, and in particular to be on their guard against those pushing agents who are ready to set up any sort of a pump without reference to the capacity of the well.

In any case, however, the introduction of power-pumps will, for a long time to come, be of interest only to the wealthier landholders as their first cost must place them beyond the reach of smaller men, who will be content to use their available cattle-power to raise as much water as it can manage. Indeed, the clearest result of a somewhat detailed study of the well system of the Province may be stated in the aphorism that protection against drought is mainly a question of supply of capital. Given capital on reasonable terms, the dwellers in the alluvium may be trusted to protect themselves with occasional assistance in overcoming engineering difficulties: and questions of construction and working fade almost into insignificance when we consider the enormous number of wells that are waiting to be made and that will be made as soon as capital is forthcoming.

Note.—The literature on the subject of alluvial wells is remarkably scanty considering their importance to the country. Practically all that is known about them will be found in two books:—

(1) *Papers relating to the Construction of Wells for Irrigation* issued in 1883 by the Department of Agriculture & Commerce of the N.-W. Provinces & Oudh.

(2) *The Manual of Irrigation Wells* drawn up by Mr. E. A. Molony, I.C.S., and issued in 1907 by the Department of Land Records and Agriculture of the United Provinces.

THE AGRICULTURAL CLASSES IN MADRAS, AND HOW TO APPROACH THEM.

By M. E. COUCHMAN, I.C.S.,

Director of Agriculture, Madras.

THE presentation of the report of Sub-Committee D. at the last Agricultural Conference at Pusa marks an epoch in the history of the Department. Most of the members of the Department have had a scientific education, and it might be expected that they would be more interested in the biological, chemical and physical problems which their work suggests, than in the practical question of how to influence the ryot. The report of this committee shows a full appreciation of the practical side of the Department's work. The following para. seems especially noteworthy :—

"It must be remembered, too, that one great essential is to find by careful local investigation the *actual* needs of the cultivators, rather than recommend outside methods which may be improvements, but are not acceptable under local conditions."

'Only the wearer knows where the shoe pinches.' Where an actual need exists, the soil is already prepared for the seed. The first requisite, therefore, is to consider in what tracts and among what classes we are most likely to meet with the desired state of things. A timely recognition of the fact that it is only under certain conditions and among certain classes that the Department can, at present, effect any improvements would have prevented much waste of money in the past. It is accordingly proposed to state as briefly as possible the lines on which the prospects of useful work appear most favourable in this Presidency at the present time. Generally speaking, the determining

factor will be the economic position of the cultivator, and not the intrinsic possibilities of the land.

As pointed out long ago by Virgil, want is the basis of improvement. Providence, disapproving of farming being made too easy, sharpens the wit of the farmer by suffering. As long as there is ample virgin land, it does not pay to cultivate the same plot continuously. It would, therefore, be a waste of time to approach the jungle tribes of the west coast and the Agency tracts, who fell and burn a fresh patch of forest each year, and grow a crop in the soil enriched with the ashes, with suggestions for improvement. Generally speaking, each addition to the gross yield of land per acre is obtained at a diminishing net profit on the capital and labour employed. We must, therefore, consider in what localities and among what classes of people engaged in obtaining a living from the land there exists the necessary stimulus to incur this additional outlay for the sake of a greater gross return. The limited resources of the Department in men and money can then be spent to the best effect. Farms will not be opened in tracts where the people are satisfied with their present position, or where such needs as they feel are due to causes beyond our control. Time and money will not be wasted in approaching classes who have no effective stimulus to wish to improve the yield from their land.

Taking the question of localities first, we should expect to find most pressure on the land and therefore the most stimulus to improvement, in the most fertile tracts. To some extent this is so, but, for other reasons, these tracts do not always offer the best scope for the introduction of improvements.

At the bottom end of the scale are vast areas of dry cultivation in regions of uncertain rainfall, such as are found in the Deccan Districts of Madras. Land is very cheap, and population sparse. The simple but effective implements and methods in common use suffice to produce a good crop when the season is favourable, at the irreducible minimum of time and trouble. In the Bellary, Anantapur and Kurnool Districts it is said that thirty acres can be cultivated with a single pair of cattle. If the

rains are favourable, a good crop is secured. The periodical failures of rain protect the land from being absolutely worked out by enforcing occasional fallows. If the rain fails, there is little lost, because little has been put into the land. Such conditions have produced a corresponding cultivator. Possessed of great physical strength and endurance, he is at the same time lazy, because in a bad year industry is wasted, and in a good year the land responds liberally to indifferent tillage.

"Better drink the water which is at hand, than run to a distance to drink milk," is a Telugu proverb which shows his attitude towards possible improvements. True, that in a year when the rains partially fail the man whose land is best tilled will get a better crop, but this would mean extra trouble, if not actually any extra expense. On the whole, the ryot's present methods, taking one year with another, produce enough to satisfy his needs. As long as this is the case, it would be a counsel of perfection to expect him to improve upon them. His methods being thus fixed, any new variety of crops introduced to him would have to be suited to those methods, as much as to the climate and soil.

This is a point which is apt to escape attention, but must be faced by those who seek to introduce superior but more delicate varieties. Till a change for the worse forces him to better his methods, or education raises his intelligence and creates a desire for a higher standard of living, the ryot's methods must be accepted as one of the conditions to which a new variety must be acclimatized as much as to the temperature and rainfall. We seem, therefore, to be on the bed-rock here, at all events in the immediate future. At the other end of the scale are the Deltas, or wet land tracts under equally favourable conditions. The water-supply is certain, and the silt ensures a certain minimum crop every year. Foresight, skill, and industry being at a discount, we find that the cultivator is perhaps the poorest specimen of his class. This is especially true of the oldest Delta system, the Kaveri Delta. Here hundreds of years of practical security against failure of crops have weakened the fibre of the cultivator,

and destroyed his initiative and resource. The high prices which the land sells for show that the present methods, defective as they are, yield a large net return. Till the existing economic conditions can be changed, there exists little prospect of a general improvement. What these economic conditions are, will be seen below. In the meantime the only hope is in the exceptional cases, where the landowner is enlightened enough to break through the prevailing practices of the district.

The most favourable localities at present seem to be those in which the climatic and agricultural conditions are such as to yield a fair return to hard work and enterprise, but not a net surplus large enough to support a large class of non-resident landowners. The best crops are those under well-irrigation. Incessant toil and a high degree of skill are necessary to obtain a living at all, but, given these, crops are a certainty. Such are the "garden" lands of the East Coast, where field crops are grown by lift irrigation from private wells, and the best cocoanut and areca gardens of the West Coast. To these must be added the districts of dry cultivation with a rainfall reliable enough to encourage the cultivators to treat their land well. It may safely be said that any practical suggestion by which their labour could be lightened, or made more productive, would receive careful consideration from the cultivators of such tracts. In such districts, criticism of farm methods is always keen and intelligent, showing that they are on the look-out for improvements.

The next division of the subject is the most important. Among the numerous grades of people interested in the land, from the naked cooly behind the plough, scarcely more intelligent than the animals he follows, to the zamindar, money-lender, or vakil living in the city, which are most likely to listen to the advice of the Department? This is a practical question, because the machinery for effecting improvements must be adapted to the subject-matter. Bulletins and instructors must be suited to influence the class to be approached.

For a long time to come the hired cooly is evidently beyond our scope. He has little voice in the matter or interest in the

result of his work. Next above him comes the "sharer," who cultivates a piece of land, or provides the labour for a crop, on condition of receiving a share of the crop. If his share is a fixed quantity of grain, he has no interest in improving the yield beyond what will be enough to secure this. If he gets a percentage, he has an interest in the result, but could not change his methods without his employer's consent.

The next class is the tenant-at-will, usually on a yearly lease. His status varies from that of a rack-rented bird-of-passage, who pays from half to three-quarters of the gross produce to the landowner, to that of the wealthy tenant of a poor landlord in a district where good tenants are scarce. Where the tenant pays his rent in the form of a share of the crop, he is naturally averse to increasing the rent paid to his landlord, even though by this means he might increase his own profit as well. An intelligent ryot in the Kaveri Delta is reported to plant his own paddy-land, about twenty acres in extent, with single seedlings, using selected seed, and manuring his land, thereby getting about double the usual crop. He also rents some land on the share system prevailing in the Kaveri Delta, whereby from half to three-quarters of the gross produce goes to the landlord. This he cultivates in the usual slovenly local fashion, preferring to get a smaller return himself with the minimum of trouble, to increasing the share of the sleeping partner in a greater ratio than his own. Even where the share system does not prevail, the tenant-at-will has reason to fear, unless protected by special legislation, that any increase in the produce due to superior cultivation will be followed by an increase in the rent. Where competitive rents are the usual thing, private landowners are not troubled by scruples about taxation of improvements effected by their tenants. It is in this Presidency the common practice for tenants to pay Rs. 100 an acre and more for land for betel or sugar-cane cultivation for which only Rs. 30 will be charged when rice is grown on the same land. There is, therefore, little use in approaching the average tenant-at-will with suggestions for improvement.

Leaving out for the moment the next grade, and working down from the top, we begin with the zamindar, money-lender, vakil, Government official and the wealthy landowning class generally. In most cases these are absentees, and practise some other profession. Their land represents their inherited wealth and their personal savings. Ask a man of this class what rent per acre he receives, and frequently he cannot tell you. He knows that land paying, for example, fifty rupees worth of rice as rent will cost Rs. 1,000 to buy. The better the land, the safer the water-supply, the lower the rate of interest. This class, as a rule, buys only the gilt-edged species of land, such as the wet land in our great Delta systems, the Godaveri, Kistna, and Kaveri, or under rivers fed by the unfailing monsoon of the West Coast, such as the Tamprapani Valley in Tinnevelly. Their interest in the land is confined to the receipt of rent; their knowledge of it derived from the scrutiny of their title-deeds. Most of this class have neither the time nor the inclination to devote themselves to agricultural improvements. A fair number, here and there, evince an abstract interest in the subject of agriculture, but, with a few bright exceptions, the mutual want of knowledge and confidence existing between them and their tenants prevents this bearing any fruit. An exception must be made in favour of the well-educated and enlightened zamindars of the younger generation. Most of them reside the greater part of the year on their properties. Some have home farms under their own management. When the zamindar succeeds to the title while in his minority, and the Court of Wards takes his property under its management, the home farms are managed by the European Expert employed by the Court. In the meantime the minor is receiving a first class education, in which stress is laid on agricultural subjects. There is good reason to hope that in many cases they will carry on their home farms on succeeding to their properties. Should these hopes be realized, more can be expected from this class than from any other.

With this exception, little help can be looked for from the larger landowners in this Presidency.

The class next below this, and next above the tenant-at-will class, is recruited from all grades of society. At one end of the scale we have the small ryot, cultivating ten or twenty acres of dry land in the Deccan plateau with one bullock of his own, and another begged or borrowed from his neighbour. Yesterday a cooly, he has obtained on *Darkhast* a piece of land on the margin of cultivation, investing his savings, of perhaps less than twenty rupees, in the purchase of an old bullock, and few cheap implements. If his first season is a good one, he may permanently rise to the status of a ryot. If not, he becomes a cooly again. The land he abandons goes to swell the total of lands bought in by Government, and provide figures which come in useful to critics of the Ryotwari system.

At the other end of the scale is the large landowner, farming part of his own land because it is his hereditary profession, and supervising the tenants who farm the rest of his property. This class also includes permanent tenants on a fixed rent, mortgagees with possession, renters for a term of years on a fixed rent; in other words, all those who have a direct interest in increasing the produce of their lands. Some of these are being continually elevated into non-resident landlords by the rise in prices, which increases their surplus profits to the point where their land will give them the income they consider sufficient without any personal supervision. On the other hand, this class is constantly being recruited from below by the best of the labouring classes. In Madras, coolies returning from abroad, with money in their pockets, and wider ideas and higher ambitions in their heads, form a small but valuable portion of this contingent. Some guide to the localities where this class can be found in the greatest numbers is afforded by the census figures. The class "cultivating landholders" forms the highest percentage (of the class Landholders and tenants), *viz.*, 90·7 in South Arcot, the home of the ground-nut, essentially the small man's crop, in Coimbatore 87·4, Salem 85·4, Trichinopoly 86·7, Madura 87·4, Tinnevelly 84·7. These are all districts where there is a large amount of well-irrigation and good dry land. In the Tanjore

Delta the figure falls to 56·8, Malabar to 11·2, Godavari 54·4. The three last districts are perhaps the richest in the Presidency, and their wealth lies mainly in their wet lands.

The proportion of cultivating owners is also high in the Bellary, Anantapur and Kurnool Districts, but, for the reasons given above, the conditions here are unfavourable for effecting improvements. The consideration of the best class to work on leads, therefore, to the same conclusion as was arrived at from the consideration of localities. The most promising field of labour lies in those districts where personal skill and attention are necessary to obtain a good living from the land. In these districts are also found the largest number of the class whom there is the best chance of influencing, because they have a personal interest in improvements. In the immediate future, till our Agricultural Colleges have commenced to pour forth sufficient numbers of well-trained subordinates of the right sort, through whom alone the masses can be approached, it is to the educated section of this class that the Agricultural Department must mainly address itself. Unlike the uneducated ryot, they are used to basing their conduct partly on reason, instead of on custom alone. They are accustomed to looking for information to books and papers, and to acting upon it. They can, therefore, be influenced by bulletins and pamphlets in English and vernacular. The ordinary ryot who can just read a vernacular paper would scarcely ever act on any information contained in it. Reading to him is a mere way of killing superfluous time, not a way of obtaining information on which to base his conduct. The educated classes have travelled, and seen other crops and other methods. Pilgrimages to distant shrines are responsible for many new introductions. The writer was once astonished to see in an unusually dry year, a rude attempt at a picotah in a remote part of Coorg, in which, owing to the heavy rainfall, any artificial method of lifting water is absolutely unknown. On questioning the owner, it was found that he had seen the picotah from the railway carriage during a pilgrimage to Benares. Numerous instances could be adduced to prove the same point

that new crops and improvements are, at present, usually introduced by the more intelligent and educated cultivators. Yet, if the average ryot is to be taught rational methods of breeding and feeding his cattle, of collecting and preserving his manure, of selecting his seed, and cultivating his land, an agency must be devised for influencing the illiterate classes. To trust to new ideas filtering down from the infinitesimal fraction of the population which is at the same time educated and takes an interest in agriculture, is to postpone progress indefinitely. The percentage of 'literate' males among the leading Tamil and Telugu cultivating classes at the last census was as follows :—

Vellalas	...	6·9
Kammas	...	4·8
Kapus or Reddies	...	3·8

Among the literates of these classes the percentage of those who know English was as follows :—

Vellalas	...	3
Kammas	...	1
Kapus	...	1

The reality is even worse than the figures suggest, for, if a member of a cultivating class has learnt English, he has usually ceased to be a cultivator. A glance is enough to prove that no bulletins in English can reach the fringe of the cultivating classes. Vernacular bulletins can be read by only a minute fraction. For the present, therefore, little would be gained by emulating the excellent farmers' bulletins and agricultural journals, the production of which must occupy a large amount of the time of the officers of the Agricultural Departments of other countries. In such countries the Agricultural Experts are usually men of the same race as their audience. Their audience is also educated, and accustomed to look to the papers and to books for information in connection with farming. Even under these favourable conditions, the tones of expostulation and entreaty which are at times discernible in these publications, seem to indicate that much of the seed falls upon stony ground. The Experts of the Indian Agricultural Department are separated by a wide gulf in language, race, customs and ways

of thought from the farmers of the country. They can never hope, therefore, to exercise any considerable direct influence on the cultivating classes.

The agricultural classes here can only be reached by oral instruction given in their own languages in their own villages. The training of the right kind of farm Managers and itinerant instructors, well, but not too highly, educated and preferably belonging to the agricultural classes themselves, must, therefore, be the most important duty of our Executive Agricultural Experts for some time to come. With this end in view, the Agricultural College at Coimbatore has been made as accessible as possible to the ryot classes. The only educational qualification which is indispensable is a knowledge of English sufficient to enable the students to follow the lectures. No scholarships are given, as it was found in the past that these attracted the wrong class of men. On the other hand, free lodgings are provided and no fees are charged for tuition. By this means it is hoped to obtain a suitable agency for "bringing experimental work to the notice of cultivators."

NEW IMPLEMENTS ON THE MIRPURKHAS FARM.

By G. S. HENDERSON, N.D.A., N.D.D.,

Deputy Director of Agriculture, Sind.

THE following series of photos illustrate some recent introductions of implements designed for the special conditions of the Sindhi cultivator. Some of these are modifications of the indigenous implements of other countries. It is considered that the Sindhi is more likely to take kindly to a simple but efficient and inexpensive tool than to more elaborate contrivances manufactured abroad.

A small workshop has been recently started at the above farm where all the following implements, with the exception of the water-lift, are made. Over 100 applications for ploughs have already been received, and it is expected that after demonstrations have been arranged in the various talukas, and leaflets distributed, the demand will be considerable.

Plough.—On irrigated lands where the ground is softened by water it is an efficient implement. The share is of iron $6\frac{1}{2}''$ broad and the body $3'$ long. It deals effectively with the numerous troublesome weeds generally found in irrigated land. The working depth is adjustable. It will do at the least one half more work than the ordinary Sindhi plough and go $2''$ deeper with ordinary bullock power. A heart-shaped piece of wood fitted into the angle between the draft pole and the body, converts it into a very useful ridging plough. The cost at Mirpurkhas is about Rs. 7. (Plate I.)

Scraper.—This is a useful implement on irrigated lands and especially on a perennial canal. To prevent waste of water it is essential that the ground should be level, and this can readily

be effected by this implement. It is a square box-like arrangement with long handles and a convex bottom, the gathering edge being of iron.

In levelling land generally one plough works along with four scrapers. The scrapers follow one behind the other and gather up the loosened earth. When full, the scraper is simply tilted over at the required spot. The earth can either be spread out evenly or made into embankments. Substantial embankments can be more cheaply and quickly constructed in this way than by doing the work by hand.

When the scraper is emptied, the rope across the handles rests on its draft chain, and it is brought back as in plate III. It is cheap. (Plates II & III.)

Norag or Thresher.—This is a useful machine for threshing any grain and is especially adapted for wheat, as it chaffs up the straw the right length for feeding. Its construction is evident from the plate. The only points which would offer difficulty to a local blacksmith are the cast iron axle bearings. If the discs are kept sharp, it will do four times as much work as the ordinary method of treading out by cattle. The usual manner of working is to pile the wheat or rice, etc., in a large heap; some of this is carefully spread on the ground on the outside of the pile forming a large circle. The "Norag" is driven round this and gradually threshes the whole heap, the circle getting less and less as the loose pile diminishes. In this way much handling of the grain is avoided as the crop is carted straight to the pile. (Plate IV.)

Iron Screw Water Lift.—On a perennial canal an efficient water-lift driven by animal power to raise water generally not more than 3 ft. and often considerably less, is greatly in need. For this purpose on the Jamrao Canal, the Persian Wheel is universally used. On a 3 ft. lift, however, this is very inefficient. A one bullock Persian Wheel on a small lift will discharge probably from ·10 to ·12 cubic feet per second. Plate V illustrates a machine giving an estimated discharge of 1 cubic foot per second on a 2 ft. lift., *i.e.*, will water an acre 1″ deep in an hour. It consists of a double spiral screw working in a masonry cylinder.

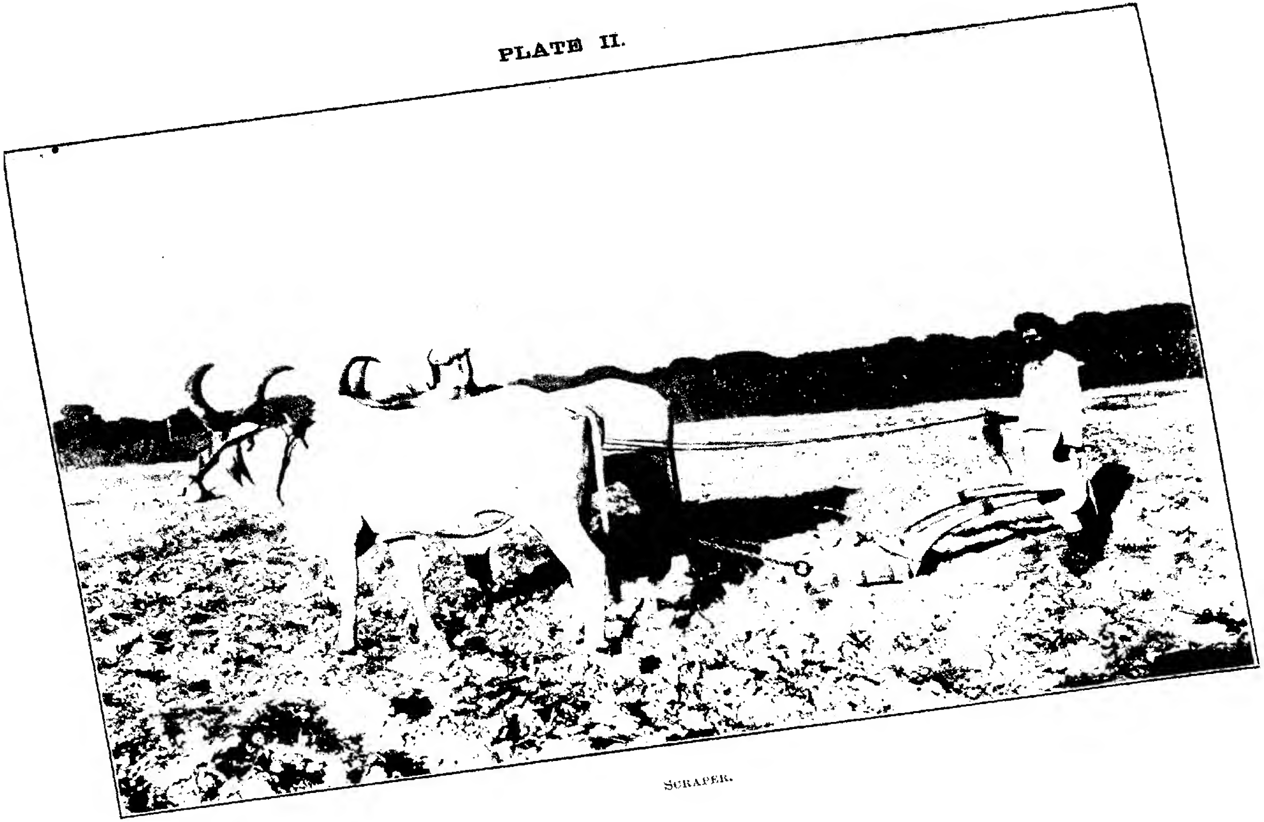
PLATE I.

A. J. I.

PLOUGH.

PLATE II.

PLATE II.



SCRAPER.

A. J. I.

PLATE III.

PLATE III.

A. J. I.

SCRAPER.

PLATE IV.

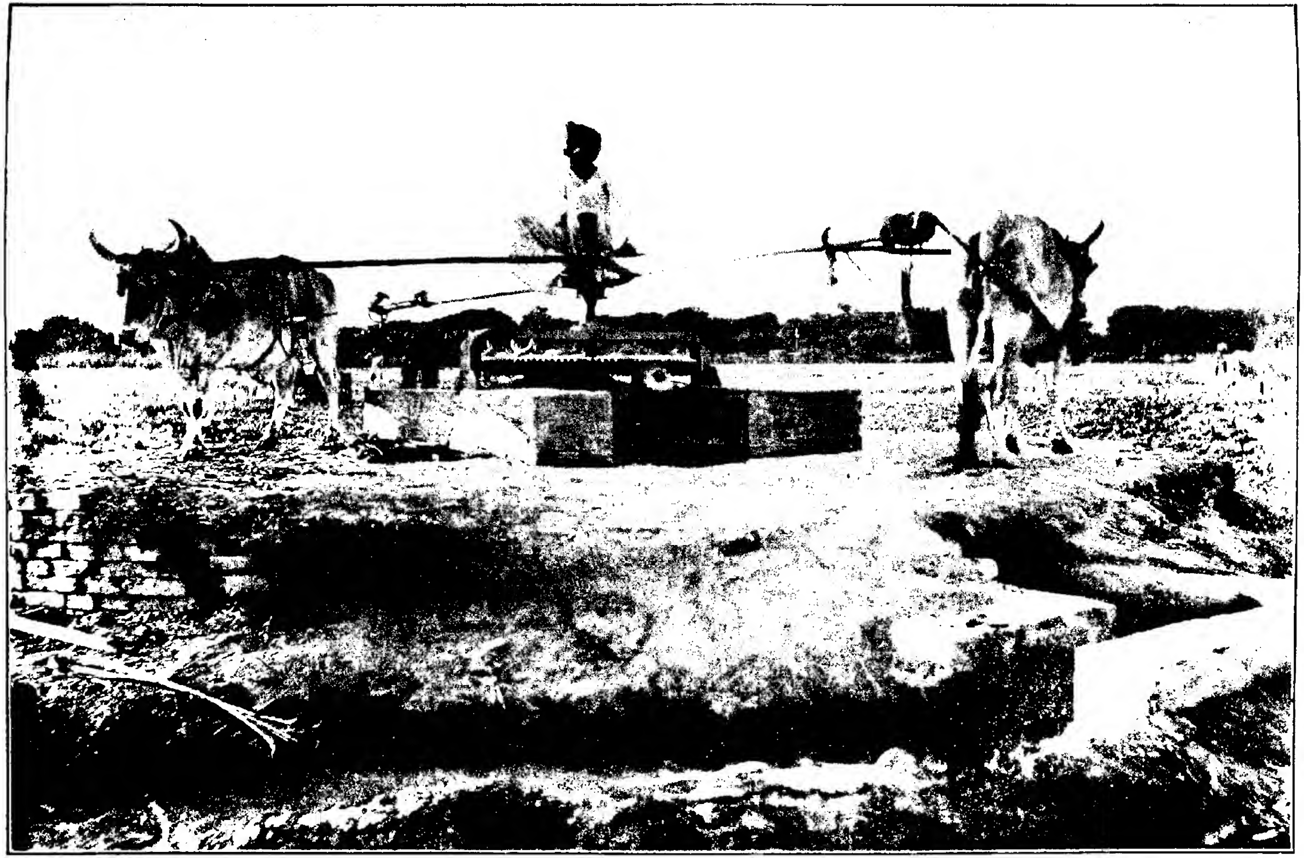
PLATE IV.

A. J. I.

NORAG OR THRESHER.

PLATE V.

PLATE V.



A. J. I.

IRON SCREW WATER LIFT.

The cost is Rs. 600/- and unlike the Persian Wheel or "Hurla" does not need to be remade or refitted each season. (Plate V.)

The photos are by Messrs. Gopaldas & Sons, Photographers, Hyderabad, Sind.

THE MANURIAL EARTH OF THE KISTNA DELTA.

By W. H. HARRISON, M.Sc.,

Agricultural Chemist to the Government of Madras.

In many of the districts of the Madras Presidency, it is a common practice for the ryots to apply regularly to their lands such earths as are found to be of benefit to the crops. These earths are either the silts which have collected in the tanks and irrigation canals, or certain soils obtained from the vicinity of habitation and villages. The latter practice is general throughout the paddy-growing portion of the Kistna District and the earth used is locally known as Pati-mannu.

Pati-mannu is obtained from the backyards of houses or from places near present village sites which, there is every reason to believe, were once occupied by houses and cattle-sheds. The Telugu ryot lives in densely crowded villages, a custom which has come down from disturbed times, and he is notorious for his devotion to his cattle. The cattle are literally treated as members of the family. The front room of the ryot's house is occupied by the cattle, fowls perch on the rafters, and the human members of the family find room for their beds wherever they can, unless there happens to be an upper story attached to the house. Village sites are seldom changed and consequently the soil in the houses and backyards becomes strongly impregnated with organic matter to a depth of 8 to 10 feet and possesses strong manurial properties.

The only use of this earth until comparatively recent times was in the construction of walls and dwelling-houses, as such structures withstand the effects of rain and heat better than those constructed with the ordinary earth of the district. In

the Ceded Districts, it is largely used for the flat mud roofs of the houses, which are proof against rain.

The use of Pati-mannu as a manure seems to have originated within recent times, as the oldest ryots deny having seen it put to such a use in their younger days and fix the time when this first occurred as about thirty years ago.

Information regarding the place to which the honour of first recognizing the value of the earth, and originating the practice of applying it to paddy-lands, must be allotted, is of the vaguest character. The ryots of Saripalli state that it was first used at Agarru, those at Agarru point out to Palakole and Palakole in turn refers to Jinnur. Although the Jinnur ryots have only very vague recollections, the balance of evidence points, as far as the Kistna District is concerned, to the practice having arisen near this village, but it is more than probable that it was an importation from the southern districts of Madras.

Pati-mannu on inspection *in situ* is found to consist of compressed heaps of organic refuse and earth. Good specimens are ash-grey in colour and crumble to a powder under very slight pressure. It is almost exclusively used on paddy-lands, the only exception noticed being in the village of Uppaluru in the Bezwada Taluq where it is occasionally applied to tobacco crops. The carting of the earth commences after the paddy harvest, at a time when the canals are closed, and during this season heaps of it can be seen lying on the wet-lands near the railway from Bezwada to Masulipatam. This work is vigorously pushed forward and the earth is spread by the end of May, so that the land may be ready for transplanting in June.

In many parts of the Delta some of the low-lying lands are poorly drained, and in these there is a tendency for saline matters to accumulate. Such lands give greatly diminished yields, and even this result is only obtained at the expense of a large amount of labour and water. The ryots use Pati-mannu in conjunction with paddy straw for the improvement of these lands. Soon after the harvest the land is well flooded with water and paddy straw is trampled in, no charge being made by the Revenue

Department for water used for this purpose. The water is allowed to remain for a fortnight before draining off, and then fresh water is admitted and allowed to stand for a further period of a fortnight. After finally draining the land, Pati-mannu is spread at the rate of 100 cartloads per acre and ploughed in. A further dressing of 50 cartloads per acre is given in the following year, followed by 30 cartloads in the third year.

Now that the supply of the earth is restricted, it is difficult to form an exact estimate of the amount applied to the paddy-lands, as this depends upon the wealth of the individual ryot, the accessibility and amount of the earth available, and the nature of the land to which it is applied. Only the wealthy ryots and landowners use it in large quantities, and their practice is to bring on to their lands a regular amount of Pati-mannu every year. This, however, is so distributed that only one section of the land receives a dressing during any one year, and it then receives no more for a further period of six years. The earth is applied in quantities varying from fifty to one hundred cartloads to the acre. Poor ryots who cannot easily command a supply often apply it once in ten years and even then in much less quantity than their richer neighbours. At Kankipad, for instance, a cultivator owning about one and a half acres of land was found to be applying to that area only 20 cartloads of Pati-mannu and this was derived from a wall in his compound. Taking the district as a whole, the general practice appears to be an application of about 75 cartloads to an acre every six years.

The price paid for Pati-mannu varies greatly with local circumstances. In some villages, the price is comparatively low and the supply good ; in others the supply is in the hands of a restricted number who trade on the misfortune of their neighbours. In other villages, the supply is retained for the use of one or two landowners, and the ordinary cultivator cannot get it at any price. At Chattaparru the earth is obtained from the fort at Ellore, two miles away, and the cost to the ryot varies from 14 annas to one and a half rupees per cartload, this price however including cartage. At Dendalur in the same taluk,

there is a large mound of Pati-mannu and one hundred cartloads can be bought for fifteen rupees. Near Gudiwada Station, the mounds cover an area of about 50 acres to a depth of six to eight feet, and these are sold to the ryots by the Inamdar at 4 annas per cubic yard.

Eliminating the excessive price paid at Chattaparru, the average cost is about thirty-two rupees per one hundred cartloads, but in order to arrive at the true cost to the cultivator, it is necessary to make an addition for the cost of cartage. This is a considerable item where long distances have to be covered and adds materially to the value of the Pati-mannu when tipped on the land. The condition of the roads must also be taken into account in forming an estimate, and it is probable that the average cost for this item for the whole district does not vary materially from twenty rupees per one hundred cartloads. The total cost to the ryot is therefore about fifty-two rupees per one hundred cartloads, and this, on the basis of an application of seventy-five cartloads per acre every sixth year, is approximately an annual charge of six and-a-half rupees per acre. In this estimate no account has been taken of the cost of spreading the earth, as this operation is usually carried out by the ryot himself and his family. In cases where hired labour is employed, payment is made at the rate of four annas per day and the cost of spreading an acre can be put down as between one and two rupees. This expenditure, however, is spread over a period of six years and does not materially affect the above estimate. In this connection, it may be pointed out that a cartload weighs approximately half a ton.

It is generally conceded by the ryots that the highest yields are obtained in the second and third years following the application, and that after the fourth year, the crops are decidedly inferior. Lands which only yield from 830 to 1,000 lbs. of paddy when untreated, will give from 1,700 to 2,500 lbs. of paddy after an application of Pati-mannu.

During the course of this enquiry, thirteen samples of Pati-mannu were obtained from different places in the delta and sub-

mitted to analysis. It was found that the percentage of $P_2\ O_5$ varied from ·505 to ·909; but if the two extreme values are ignored, the variation is only from ·664 to ·790 per cent. The percentages of potash are, however, very variable, the limiting values obtained being ·52 and 2·02, and between these limits the intervening values were evenly dispersed.

An average sample was prepared from the specimens collected and the following shows its composition: –

Moisture	4·20%
Loss on ignition	1·22%
Insoluble mineral matter	75·51%
Ferric oxide	3·25%
Alumina	6·57%
Lime	2·60%
Magnesia	·78%
Potash	1·39%
Soda	·32%
$P_2\ O_5$	·69%
CO_2	·32%
	99·85
Nitrogen...	·094%

Pati-mannu may be looked upon as an earth rich in Potash and Phosphoric acid, and on the basis of this analysis, the amount of plant-food supplied to the land by its agency averages 13 lbs. of Nitrogen, 194 lbs. of Potash and 96 lbs. of $P_2\ O_5$ per annum.

The deficiency of this earth in Nitrogen is made good by the almost universal practice of growing sunn-hemp for fodder immediately after the paddy is harvested, and ploughing in of the stubble.

The mechanical analysis shows it to be chiefly composed of finer grade particles, but the amount of clay present in it is only 14%.

The amount of Pati-mannu now available is very limited. and in several parts of the district it is very scarce indeed. Throughout the whole of the Masulipatam Taluk, the sources of supply are practically closed to the ordinary cultivator. Until very recently each ryot had his own supply, which was derived

in most cases from his own backyard and even from the floors of their houses, and in consequence, unsightly pits, some of them ten feet deep, can be seen in and about dwelling-houses, forming such a menace to life and limb, that the Revenue authorities are insisting on the pits being filled in with earth.

In many villages, it is no uncommon sight to see walls, which are constructed of this earth, in process of being demolished and carted away to the fields. Poor ryots are known to sell their houses to be broken up for manure and to rebuild them with the ordinary delta earth.

Cattle manure is exceedingly scarce, as the number of animals kept by the ryots is comparatively small, and the greater part of these are sent away to distant grazing grounds during certain parts of the year. What little is available is chiefly used in the preparation of seed-beds.

Under these circumstances, it has become of imperative importance to afford some relief to the poorer ryots, by introducing some cheap and effective substitute to their notice, and experiments are now being carried out by the Madras Department of Agriculture to further this object.

Cheap mixed fertilizers, the components of which, with the exception of the potash, are easily obtained locally, have been prepared by the Presidency Manure Works, Ranipet, to the specification of the Madras Agricultural Chemist, and enough for about forty acres has been distributed free to selected cultivators near Ellore and Bezwada. Should success be attained, an enormous demand for an artificial fertilizer will accrue, as there are 250,000 acres of wet land in the Kistna Delta alone. It is thought that the fact that these ryots are familiar with the use of a mineral manure will increase the chances of success.

TATA SERICULTURE FARM AT BANGALORE.

By J. MOLLISON, M.R.A.C.,

Inspector-General of Agriculture in India.

THE late Mr. J. N. Tata established at Bangalore a small Sericulture Farm about 1898. It was started to help native rearers to control such diseases as affect silk-worms in India, and generally to give technical instruction in growing suitable kinds of mulberries, in rearing silk-worms, in reeling silk and preparing it for market. The little farm has answered these purposes admirably.

Mr. Tata was familiar with Japanese methods. He considered them well suited to India. He got for the supervision of his farm one Japanese Expert of the artisan class and another who knew sufficient English to act as interpreter.

The fittings and reeling machinery for this small factory were mostly imported from Japan. They are simple, durable, inexpensive and efficient. They were put up by the Japanese Artisan Expert helped by an Indian *mistri* and coolies. The Japanese Expert and his wife trained native girls of 10 to 14 years of age to do the reeling. I have repeatedly seen these girls at this work. The work was excellently done.

I compare in the accompanying tabulated statement this work as done by a fieldman of my office after three months' training at Bangalore, and the work done by the most expert reeler in the factory—a young girl.

REELER.	Nos. of coons.	Time occupied in reeling.		Time occupied in re-reeling.		Breakages of fibre at time of re-reeling.	DENIERS TO TEST SILK.				Waste of silk.	Pure silk obtained.
							Beginning of reel.	Middle of reel.	End of reel.	Average.		
		H.	M.	H.	M.						Ozs.	Ozs.
Girl ...	1,500	6	0	2	34	*Nil*	14 14	13 14	13 14½	13-33 14—16	1—54	3—40
Fieldman ...	1,500	13	30	3	0	26	16 16½	17 18	16 15½	16--33 16—66	1—86	2—89

The motive power for reeling and re-reeling by 12 operators was done easily by a woman slowly working a wooden lever, and this power could have easily done much more work. The 12 girls could, in a day, reel and re-reel about 2 lbs. silk, which was worth at the time of my last visit 17*s.* 6*d.* per pound in England. The value of the refuse silk was a considerable additional item of income, but was not estimated.

The work of mulberry cultivation, rearing silk-worms, improving varieties of silk-worms by cross-breeding, detecting diseases by means of the microscope, preserving cocoons for seed and for hanking, pressing and packing the silk for market, was thoroughly done. Apprentices were taken in free for instruction. A three months' course was required for this purpose.

Bush mulberries only were grown. The rainfall, average temperature and soil at Bangalore and generally throughout the Mysore plateau, appear to be well suited for the cultivation of bush mulberries. Those grown were three grafted Japanese varieties, one Italian variety and four others, probably Indian. The Japanese varieties cannot be propagated from cuttings; the others can. Plants of the Japanese varieties and cuttings of the other varieties can, I understand, be supplied to those interested in sericulture.

The soil of the garden is a good deep dark red loam. Cuttings are first put in a nursery, and when they have rooted, are planted out 5 to 6 feet apart in each direction. In order to maintain a succession of young leaves throughout the year, the various plots are pruned in regular succession and irrigation given when required. Crude sewage and night-soil are used as manure with excellent results.

Young leaves are required for the larvæ when newly hatched. If there is a full supply of these and of more mature leaves when the worms are larger, six or seven broods are reared in 12 months.

Disease prevails extensively in Mysore. The following results were obtained from seed cocoons obtained locally :—

(1) 615 moths laid eggs.

(2) 114 of these moths were diseased as determined by microscopical examination ; therefore the eggs were destroyed.

(3) The larvæ from 501 batches of eggs hatched out.

(4) These silk-worms ate 3,566 lbs. of green leaves.

(5) The leaves were obtained from 2·41 acres of bush mulberry in full vigour of growth.

(6) 270 lbs. of cocoons were obtained.

At Bangalore, bush mulberry plantations get worn out even with careful pruning and cultivation in a few years. Young plantations to replace old should, therefore, be formed from time to time. Rotation is desirable. A ten-acre area should probably have 5 acres under plantations established for three or four years or longer, and 5 acres under a nursery, young plantations and other crops. The whole should yield leaves sufficient for 6 or 7 broods in a year, each as large as that referred to above or larger.

Mr. Tata's Expert recommends that the rearing house should be separate and at a distance from the buildings required for storing cocoons and reeling with the object of avoiding the risk of communicating diseases. The rearing building should be constructed so that light and ventilation are fully secured; a thatched roof and a verandah being desirable to keep the day and night temperatures fairly equable.

Expensive construction is unnecessary. A mud floor does very well. There should be a plinth and, exclusive of verandah, a building 20′ × 16′ is sufficient. The height to eaves should be 10′. The north verandah should be about 10 feet wide and enclosed to form a room. If well lighted, the moths, as soon as they have laid their eggs, should be examined for disease under the microscope in this room, which should have no direct connection with the rearing house. The healthy eggs only should be kept.

In the rearing house, there should be three wooden stands each 5 feet high, three feet wide, each with three shelves, the lowest shelf should be 18 inches from the floor. These stands should be so placed that there is easy access to each. They are required to support the trays in which the silk-worms are fed.

A brood from 600 batches of eggs can be accommodated in one tray when first hatched out, but requires about 150 trays when fully grown.

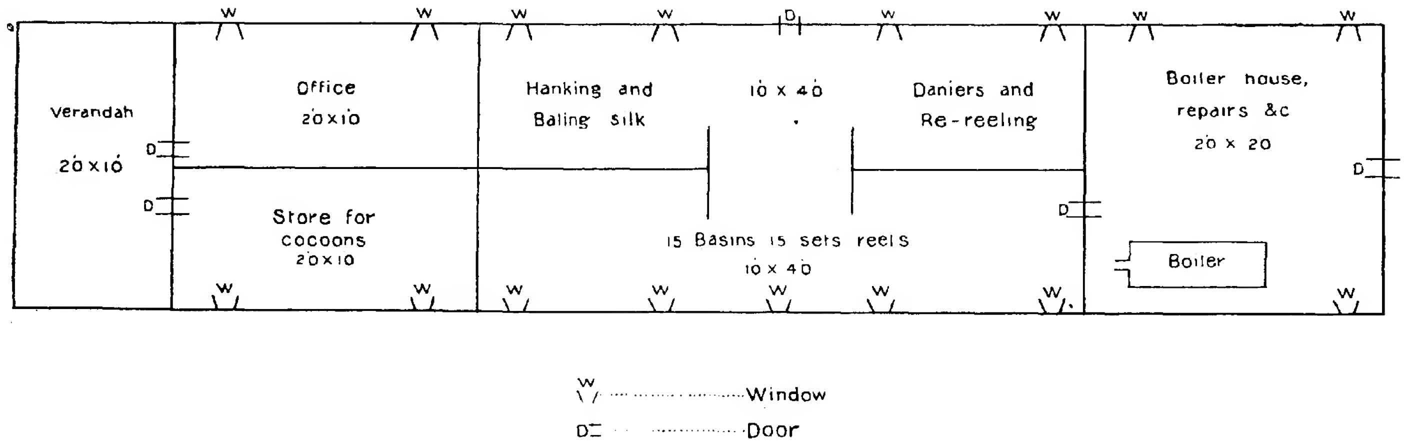
The detailed cost of the fittings of the rearing house is :—

		Rs.	As.
1.	Three racks constructed of wooden frame and split bamboo shelves	30	0
2.	One rack for storing trays, etc. (not in use)	10	0
3.	One table and plank of wood on which the leaves are cut, with a long knife	10	0
4.	Sharpening stone	2	0
5.	A set of four sieves each with different size of mesh for sifting chopped leaves	3	0
6.	160 skeleton bamboo trays, $3\frac{1}{2}' \times 2\frac{1}{4}'$, at 4 annas each	40	0
7.	160 mats, at 4 annas each	40	0
8.	160 nets, $\frac{1}{4}$ inch mesh, at 3 annas each	30	0
9.	Four wooden stands for trays at time of feeding	4	0
10.	24 cocoon spinning screens (*chandrikeis*)	24	0
11.	One Dissecting Microscope, Zeiss	122	0
12.	Table and almirah in verandah room	25	0
	Total Rs.	340	0

The reeling factory should be $90' \times 20'$, and contain (*a*) an office $20' \times 10'$, in which the records should be kept, also in which cocoons for seed and baled silk should be kept ; (*b*) a room $20' \times 10'$ for drying, cleaning and storing cocoons ; (*c*) a verandah $20' \times 10'$, common to (*a*) and (*b*), can be used for drying cocoons in wet weather ; (*d*) a room for reeling, etc., $40' \times 20'$, partially partitioned longitudinally in the middle. On the one side of the partition the basins and reels should be ranged longitudinally ; on the other side, the silk should be tested and re-reeled at one end, and hanked and pressed into bales at the other end ; and (*e*) a boiler house $20' \times 20'$, with an arrangement for steaming cocoons to kill the pupæ. The hand-motive-power should be worked in the boiler house and also the blacksmith and carpentry work done.

The whole building should be constructed on a plinth with brick walls, 10' feet high to eaves, with tiled roof. The reeling room should have a paved floor and arrangements for drainage.
121 Mud floors are suitable for the other rooms.

Fig. 3.



Verandah
20 x 10
Office
20 x 10
Store for
cocoons
20 x 10
Hanking and
Baling silk
10 x 40
Daniers and
Re-reeling
15 Basins 15 sets reels
10 x 40
Boiler house,
repairs &c
20 x 20
Boiler
W ... Window
D ... Door

I give a rough ground plan on previous page (Fig. 3). The reeling apartment is of sufficient length for at least 15 basins and 15 sets of reels, and the other accommodation is practically proportionate.

The office will require ordinary furnishings with a vermin proof cupboard for storing seed cocoons. The furnishings are estimated to cost Rs. 50. The store for cocoons should have a large central rack or stand on which in three tiers the cocoons can be stored—

	Rs.	As.
Estimated cost of rack	50	0

The fittings of the reeling apartment at Bangalore cost for 10 reelers as under :—

	Rs.	As.
10 Boiling basins	12	8
10 Reeling basins	20	0
10 Water cups	5	0
1 Reeling table, 20′ × 2¼ × ½	90	0
10 Brass water taps	23	0
10 Steam regulators with couplings	63	0
2 Brass bill corks	5	0
10 Reeling machines on platforms with 80 reels 4 Reeling machines and 16 reels	843	0
Apparatus for baling and testing silk	100	0
Small appliances	20	0
Packing and freight charges from Japan	250	0
Rs.	1,431	8
A Cornish boiler, 7¾ × 2½, with fire box fittings and chimney and freight charges from Madras	1,265	0
Erection of boiler and setting up machinery in working order with carpenter's and blacksmith's tools, etc., for repairs ...	645	0
Rs.	1,910	0

I do not know the actual cost of the Bangalore buildings. They were simple and inexpensive.

The recurring expenses for cultivation should not exceed Rs. 50 per acre per annum and probably will cost less.

Mr. Tata paid his Japanese Expert Rs. 150 per month at first; now he is also given, I understand, a commission on results.

RESEARCH WORK ON INDIGO.*

By W. POPPLEWELL BLOXAM, B.SC. (LOND.), F.I.C.

REVIEWED BY J. H. BARNES, B.SC., A.I.C., F.C.S., R.I.P.H.,

Agricultural Chemist, and Principal of the Agricultural College, Punjab.

THE report is divided into four sections, the first of which mentions in brief outline the work done in India by Bloxam, Leake, and Finlow, at Dalsingh Serai, during the years 1902—1904.†

The chief result of this first report was to show the necessity, in the author's opinion, of an accurate and trustworthy method for the analysis of indigo, and he considered that all work on biological lines must remain at a standstill until this point had been satisfactorily cleared up and the analysis of indigo placed on a sound scientific foundation after which it would be possible to investigate the efficiency of the manufacturing methods, and the losses which occur there.

Starting with the estimation of indigotin by means of potassium permanganate, the author had been led to conclude that this method of analysis, even with the improvements suggested by Rawson and Grossmann, was of an empirical nature and of insufficient scientific exactitude, and with the object of improving upon it, a study of the sulphonic acids was undertaken and the composition of their potassium salts determined. The potassium

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* Report to the Government of India containing an Account of the Research work on Indigo performed in the University of Leeds, 1905-07, by W. Popplewell Bloxam, B.Sc. (Lond.), F.I.C., with the assistance of S. H. Wood, B.Sc.; I. Q. Orchardson, B.Sc; R. Gaunt, Ph.D., M.Sc.; and F. Thomas, B.Sc.; and under the general supervision of Mr. A. G. Perkin, F.R.S., F.I.C., of the University of Leeds.

† Account of the Research work on Indigo carried out at Dalsingh Serai from 1903 to March 1904 by W. P. Bloxam, H. M. Leake and R. S Finlow. Bengal Secretariat Book Depôt, 1905.

salts of the four mono-, di-, tri- and tetra-indigo sulphonic acids were prepared and their composition confirmed by analysis.

This being done, Mr. Bloxam and his collaborators then proceeded to study the conditions under which the sulphonation of pure indigotin takes place without loss, an unsuccessful issue to which would render useless Grossmann's method of removing the impurities, as any loss in sulphonation would render the whole process valueless.

Wangerin and Vorländer* state that between the temperature of 95° to 100° C. a loss occurs with an acid of so low a strength as 94 per cent. when heated for half an hour; an acid of 100 per cent. strength gives rise to a loss of 2·4 per cent. in one hour between 95° and 100° C., while an acid containing 8 per cent. of fuming sulphuric acid gives rise to a loss of 8 to 14·2 per cent. according to the time of heating (half to 1 hour).

The results of the author's investigations do not confirm these figures as with pure indigotin no loss was experienced on using 20 per cent. fuming acid for three-quarters of an hour at 97° C.

The tables which follow to prove the author's contentions are noticeable, in that the quantity of permanganate used in the titration is very small, and consequently any error in titration will be considerably magnified in calculating out the results. It would be an advantage if a larger quantity of the sulphonated indigotin solution could be taken for analysis so as to minimise this error as far as possible.

Having made out the case for the pure potassium salt of indigotin tetrasulphonic acid, and shown that no loss occurred in the sulphonation, it remained for the author to prove that sulphonation without loss also takes place when the pure indigotin is mixed with varying quantities of the impurities which naturally occur in indigo cake, such as indigo glutin, indigo brown, and kaempferol; this was done with satisfactory results, and the author states that no difficulty is experienced in working the process on crude indigo varying from 36 to 74 per cent. in indigotin content,

* Zeits f. Farben und Texilchemie, 1902, 1, 281.

and recommends the process as suitable for the analysis of the crude cake of any degree of purity and at any stage of its manufacture.

The authors recommend that in carrying out this process with crude indigo, it is advisable to use fuming sulphuric acid of 5 to 10 per cent. greater strength owing to the diluting action of the impurities : probably what takes place is that the sulphonation proceeds in stages—the impurities being more easily attacked by the acid than the indigotin.

The conditions of sulphonation having been determined, Grossmann's method of purification with calcium carbonate was tested, but here it was found that all the sulphonated impurities were not removed—the analysis with potassium permanganate consequently gave too high a reading impurities being recorded as indigotin, whilst in other sulphonated products indigotin was precipitated with the impurities and consequently results were too low. The authors, therefore, conclude that the successful application of potassium permanganate to the determination of indigotin depended on the purity of the indigotin solution titrated, and that its application to the analysis of synthetic and crude indigo was not possible in the several processes recommended for the preliminary purification of the crude cake, as these all fail to remove the impurities completely and consequently too high results were obtained in the subsequent analysis : or in the cases when the impurities were completely removed, indigotin was also thrown down and the results of the titration were too low.

Knecht's method for the estimation of indigotin by titration with titanium trichloride was tried, but here the authors found it necessary to introduce some modification in (1) the relative concentration of the solutions of indigotin and titanium trichloride, and (2) the relation of tartaric acid to mineral acid present during the titration.

In order to separate the tetra-sulphonate in a state of purity, the potassium salt was salted out by the addition of potassium acetate with what the authors claim to be quantitative accuracy.

It is worthy of note in this connection that the two chemists to whom the method was subjected for criticism remark (1)* that "the new method of analysis appears to be a distinct advance on the existing methods, as the isolation of a pure indigotin compound from commercial indigo renders the analysis with potassium permanganate much more satisfactory than hitherto. But at the same time care is necessary in carrying out the analysis, for if the author's directions are not followed, the results will probably be *too low*. It is during the process of sulphonation that *great* care must be taken, for if during this process caking occurs, some of the indigo may be destroyed, or if in the salting out of the pure indigotin tetra-sulphonate the operation is not carefully watched, loss may occur; again, if sulphonation is insufficient and some of the tri- or disulphonate is formed, the final results will be too low." (2)† "When working with pure indigotin, the colour of the filtrate (very pale blue) was such as to indicate the presence of more than a negligible amount of sulphonate" Bergtheil also criticises this point and notes that potassium acetate appears to have some chemical action on the sulphonate, so that any inference as to loss of indigotin, based on the colour of the filtrate, may be misleading.

In the course of the first two papers advancing the new tetra-sulphonate method of analysis, Bloxam and his collaborators, in comparing the results obtained with the older and existing methods, offered a considerable amount of criticism on the latter, and it is but fair to note that in many cases the authors of these ascribe the failure to obtain reliable and uniform results to faulty working of the processes.

In view of this lack of uniformity and of the severe criticism of one author's work by another, we shall await with interest the confirmation of these results by some chemist who will be able to give the time to a complete résumé of all the various methods of analysis of either pure or crude indigo; for thus only can we expect

* Prof. J. Norman Collie, F.R.S., Professor of Organic Chemistry, University College, London.

† Mr. A. C. Chapman

to clear up the existing difficulties in such fundamental questions as the correct indigotin factor for the permanganate solution and the influence of concentration on the results of the analysis.

Now, though the accurate analysis of indigo itself is important, the determination of the quality of latent indigotin (or indican) which the leaf contains is a question of far greater importance in the selection of the best existing varieties, and in studying the efficiency of the manufacturing processes. The authors first tried Rawson's persulphate method, but found it was open to some error, oxidation of the glucoside indican apparently preceding hydrolysis, with the result that as much as 20 per cent. loss was experienced in the analysis. The loss had been already noted by Bergtheil and Briggs * who had proposed an alternative method of applying the reaction.

The source of indigotin or indigo blue in the various members of the indigofera is the glucoside indican which was first isolated and named by Schunck,† and many of the methods proposed for the analysis and valuation of the leaf, and the consequent improvement of the manufacturing processes have aimed at the separation and subsequent hydrolysis of this compound.

Beijerinck‡ in discussing indican suggests the possibility of estimating it by taking advantage of the well-known Baeyer§ synthesis of indirubin by the condensation of indoxyl with isatin. This suggestion involves the estimation of indican by warming its solution with hydrochloric acid and isatin, and determining the amount of indirubin produced, and was further commended by Beijerinck to the authors.

The method was consequently put to an exhaustive test and the following relations established between the three methods :—

Rawson's method	... 56
Persulphate method	... 70
Isatin method giving indirubin of 95 p. c. purity	... 88

* *Journal of the Society of Chemical Industry*, 1906, 734.

† Jahresberichte uber die Fortschritteder Chemie, 1885, 659 : 858, 465 ; and *Chemical News*, 37, 223.

‡ Proc. K : Akad : Wetensch : Amsterdam. 1899, 120.

§ Berichte, 14. 1745.

This last means an increase of about 50 per cent. over Rawson's method. It is necessary to note here that the persulphate method quoted is the author's modification of Rawson's process and has been criticised by Bergtheil* who shows that this method of applying the reaction will only yield satisfactory results when the plant extract contains a certain proportion of indican; if the concentration of the glucoside alters, the process fails, lower results being obtained.

The point is one of some importance and requires further investigation, as the critical application of these figures to the efficiency of Mahai, as calculated in India, shows that the leaf possibly contains some 20 per cent. more colour material than has hitherto been supposed, and would consequently indicate that the efficiency of the manufacturing methods in use have been over-estimated.

It would be of interest to know what results would be obtained by the application of this modified persulphate method to the analysis of solutions of pure indican at different concentrations.

An examination of the reaction between isatin and indican showed that it was a quantitative one and we† have reason to believe that the isatin method is one which will give us an accurate record of the indican contents of the leaf, always providing that the other organic materials present will not interfere with the reaction. But in connection with this point we note that on page 43 the authors state that the purity of the indirubin thus obtained from the reaction between "plant extract" and isatin was 95 per cent. as determined by Knecht's method of analysis with Titanium trichloride. Now, granting that this method of analysis will give us an accurate indication of the percentage of indirubin in the precipitate, it is evident from these figures that the product obtained some 5 per cent. of impurities. In the discussion which followed the reading of this paper.

* J. S. C. I., 1907.

† Perkin and Bloxam. *Journal of the Chemical Society*, 1907, 91—1715.

Professor A. G. Perkin stated that he believed the reaction to be quantitative, and it was very unlikely in the process used that any isatin could be reduced to indoxyl, but the reactionability of isatin towards hydrocarbons of the aromatic series, phenols, etc., in which condensation products are formed, seems to have been overlooked, and it would have been instructive if the author had examined the nature of this 5 per cent. impurities, for this impairs the reliability of the process as one of scientific accuracy. We consider that as the method stands at present, it will be necessary to check the indirubin contents of all such precipitates obtained in the analysis of the plant extract, by some such method as Knecht's estimation, and with this addition the isatin process of analysis promises to prove one of great utility in the selection of plants of the Indigofera.

Adjoined is a table* of analysis of dried indigo leaf (taken from the report), and comparing the results of the persulphate method and the determination by the isatin process, we see the apparent value of the latter over the older process.

Variety of leaf.	Indigotin by persulphate method.	Indigotin by isatin method.
	Per cent.	Per cent.
1. Indigofera arrecta, old leaf	0·67	0·87
2. Do. do. young leaf	1·48	1·81
3. Do. sumatrana, young leaf ...	2·43	3·13
4. Do. do. do. selected ...	......	3·53

These figures are of particular interest from the point of view of the indigo producer and have an important bearing on the conclusions drawn by the author as to the efficiency of the manufacturing processes at present in vogue in India.

The specimen (4) which he states to be a dried selected specimen of the *Indigofera sumatrana* yields by the new method of analysis 3·5 per cent. of indigotin (calculated from the indirubin precipitate) or about double the amount of available colour in the specimen of *I. arrecta* examined.

* Page 58.

This on first examination seems a startling discovery and indicates that the planters' stand to again double their output by the use of such a variety of Sumatrana, for the replacement of the old indigo commonly used in Bengal (the *I. sumatrana*) by *I. arrecta* has already in the last eight years doubled the yield of indigo per acre and thus been the means of saving the industry from total extinction.

But if we examine this figure of 3·53 per cent. of colour on the dried leaf, we find that though well above the average, it is not the highest recorded figure for Sumatrana, while the average colour contents of the Arrecta is even higher. Taking 70 per cent. as the average moisture contents of the green plant, and 3·53 as Indirubin of 95 per cent. purity, and the author's figure of 60 per cent. of leaf, we find that the figure 3·53 on the dried leaf indicates a green plant containing ·6 per cent. of indigotin, whereas the average accepted figure for *I. arrecta* is 1 per cent. and often higher.

It is not clear from the report how the author arrives at his opinion that the *average* indigotin contents of *I. sumatrana* is about ·6 per cent.,* and proof is required before this can be accepted as an established fact, and in consequence of this the statement† that the highest efficiency of Mahai does not reach 50 per cent. of the total indigotin available, while the average efficiency is 25 per cent. falling thence to 12·6 seems to be based upon insufficient scientific evidence.

The whole question of the efficiency of the manufacturing methods is of the greatest importance to the industry, for its survival largely depends upon the economic possibilities of improvement in this direction. The introduction of the *I. arrecta* has done much; it has enabled the planter to double his output of cake indigo, and though it is recognised by all scientific men who have given any thought to the problem that work is needed in the breeding and selection of the indigo plant on an indican content basis, we must also look to improved methods of extraction

* Report, pages 29 and 96.

† Ibid., page 29.

on the most approved scientific lines if natural indigo is to compete on anything like level terms with the synthetic product. Many of the results obtained by the author in the comparative analysis of the leaf, and the assay of commercial indigo cake have a far-reaching effect in dealing with the calculation of the efficiency of Mahai; if, for example, the increased indication of colour contents yielded by the isatin process is, as the authors state, some 20 per cent. in advance of other methods of analysis, and if the leaf contents of the plant average 60 per cent. instead of 40, then, allowing for lower result yielded by Bloxam's permanganate factor for indigotin, the application of these figures to the 85 per cent. efficiency, as calculated by Bergtheil, reduces this figure to an efficiency of 43·7. It is, however, recognised from the analytical examination carried out by Messrs. Rawson and Bergtheil that the process of manufacture commonly in vogue wins only some 50 to 60 per cent. of the colour present. If we apply the above stated correction factors of Bloxam, we obtain as a result a 28 per cent. efficiency for the planter's method of manufacture, and it would thus seem as if improved methods of manufacture could place the planter beyond the effects of competition.

An objection has, however, been raised (see above) against a comparison of the isatin method of analysis with a modified persulphate process which is at present open to criticism. This criticism, together with the noted wide divergence between the leaf estimation as carried out by the author and Messrs. Rawson and Bergtheil, show that it will be necessary to have these results confirmed by further work, and the matter placed beyond doubt before the figures can be taken as representing commercial possibilities or the planters advised to invest capital.

Before leaving the portion of the report which deals with the isatin method of analysis, it will be of interest to look into the application of the reaction and see how the authors deduct an indigotin content from its use.

When indoxyl and isatin interact, there is formed the alpha indogenide of pseudo-isatin, indirubin, and the conditions under

which the beta indogenide-indigotin are formed, appear to be very different.

These two bodies are apparently isomeric and have the same empirical formula, but differ constitutionally; they have different properties, and the conversion of the alpha body into the beta does not appear to be possible,* so that the results of this method of analysis in which the product is weighed as indirubin would be better recorded as weight of indirubin found and corresponding percentage of indican.

The importance of this point is brought out in the subject-matter of the report itself.† When experiments were undertaken with the pure glucoside indican, it was found that solutions of this body could be quantitatively estimated as indirubin by the isatin process, but, on the other hand, the authors did not succeed in obtaining a yield of indigotin, which corresponded with the quantity of colour theoretically present.

Whether this problem can yet be solved still remains to be proved; that it is a point of importance is evident after a close perusal of the subject, but the practical results of the manufacturing inform us that though we can increase the percentage yield of indirubin at the expense of the indigotin (as in the ammonia process), all the known changes rung on the various processes of manufacture have failed to materially increase the yield of indigotin at the expense of the bye-products.

In connection with this conversion of indican into indirubin, Maillard‡ concludes from experiments carried out on chloroformic solutions, that there are most probably two isomers of indigotin—the very soluble and transformable indigotin represented by the formula of Baeyer, and the ordinary stable indigotin which is probably a polymer (di-indigotin), ($C_{32}H_{20}N_4O_4$), and the

* Marchlewski & Radcliffe, J. S. C. I., xvii, 430, claim to have converted indirubin into indigotin, but no quantitative figures are given, and as their results are based only on a dye test, the question at present seems to be an open one.

† Page 94.

‡ Comptes Rendus, 134 (8), 470-72.

cryoscopic determination of the molecular weight by Vauber confirms this view.

A solution of indirubin in chloroform, on the other hand, does not undergo transformation into indigotin, but it is just possible that an unstable or "nascent" indirubin might do so, and that ordinary indirubin is a polymer or di-indirubin.

With the addition of the necessary check to the purity of the indirubin obtained (as indicated above), the results given by the isatin method of analysis then would appear to be most valuable in recording the "indican" contents of the leaf, and as this is the source of the indigo of the manufacturing process, a valuable contribution has been added to our methods of plant analysis, and should prove a specially useful laboratory check in studying the problems connected with the occurrence of indican in the plant and in plant selection.

The next and a most valuable part of the report is that which contains the author's work on indican and the naturally occurring impurities in cake indigo, and we can only say that the work here recorded is a valuable addition to our knowledge of this subject—the paper on indican by Perkin and Bloxam* being specially worthy of mention as a model of clear and concise chemical research.

The results of these investigations indicate that the indoxyl glucoside contained in the leaves of the *I. sumatrana* and *I. arrecta* is in both cases identical with the indican first isolated in a crystalline condition by Hoogewerff and ter Meulen† from the *Indigofera leptostachya* and from the *Polygonum tinctorium*.

By employing acetone as the solvent for the glucoside the authors have shown that it is easy, in the case of the *I. sumatrana*, to rapidly prepare large quantities of the pure substance, in amount equal to about 3 p. c. of the air-dried leaf. With the *I. arrecta* the process, though effective, is not so simple, and the difficulties arise chiefly from the presence of a sugar-like

* J. C. S. trans., 1907, 91—1715.

† Proc. K. Akad.: Wetensch. : 1900, 2520.

compound ($C_6 H_{12} O_5$), possibly a modification of quercetol which renders crystallisation difficult.

As the isolation of indican can be carried out entirely without the aid of heat, it is evident that the contention of Schunk* in so far as his work with the *Polygonum tinctorium* is concerned, that crystalline indican is an alteration product of his own compound, cannot be upheld.

The authors endorse Hoogewerff's and ter Meulen's statement that indican has the formula $C_{14} H_{17} NO_6$ and crystallises from water with three molecules of water of crystallisation, but its melting point in this condition is 57°—58°C., and not 51°C. as stated in their paper.

Other physical properties and the formation of anhydrous indican are also described. The authors then go on to show that by means of isatin, indican can be quantitatively estimated as indirubin, but, on the other hand, no theoretical yield of indigotin has yet been obtained.

The work of Hazewinkel in which he proves that indican is the indoxyl glucoside of dextrose was confirmed, but the authors note that on hydrolysing the glucoside with hot dilute acids the indoxyl liberated condenses with the formation of brown amorphous products and with the simultaneous production of a trace of indole.

The main product of the reaction which is here termed indoxyl brown has a percentage composition almost identical with the main constituent of indigo-brown, which it very strongly resembles.

	Resulting product of the action of acids on Indican.	Main constituents of Indigo-brown.
Carbon	68·10	68·57
Hydrogen	4·10	4·28
Nitrogen	9·34	10·00

This point is advanced in further support of the opinion expressed in an earlier communication† where the results of the

* *Chemical News*, 1900, 82, 176.

† Perkin and Bloxam, J. C. S., trans., 1907, 91—279.

author's investigations on the constituents of indigo-brown showed that these bodies were probably derived from indoxyl. The percentage of carbon which they contain, together with the fact that they are partially converted into anthranilic acid on boiling with strong alkali, tend to confirm this view.

As derivatives of indoxyl, it is probable that they have been formed by some process of condensation during or after the hydrolysis of the glucoside.

A further study of this question and other points which bear on the behaviour of indican under the conditions which exist in the manufacturing processes on a large scale are being investigated, and it is hoped that further light will be thrown on the relation of indigo-brown to indican, and on the determination of the conditions under which indican yields the maximum percentage of indigotin when acted on by acids or by the enzyme. The results of this branch of the work will be awaited with interest, for they will probably have a profound effect on the manufacture of natural indigo and the industry generally.

The cause of the fermentation process which indigo undergoes in the steeping vat has attracted the attention of many workers. It was first thought that a specific micro-organism brought about the change.* Van Lookeren and Van der Veen suggested the presence of a hydrolysing enzyme, but brought no experimental evidence forward.

Breaudat† obtained evidence of the enzyme when working on the *Isatis alpina* and concluded that in the latter there was also an oxydase which produced indigo from the products of hydrolyses of the glucoside.

Beijerinck‡ found that several commonly occurring aerial micro-organisms were capable of the production of indigo from plant extract, but considered that the hydrolysis in the steeping

* Alvarez (Comptes Rendus, 1887, 115-286).
† Landw. Versuchs. Stat., 43, 401.
‡ Proc. K : Akad : Wetensch : 1900, 120.

vat was brought about by an enzyme, and the view was supported by Hazewinkel* and Van Romburgh.†

They state that the enzyme is insoluble in water and only slightly soluble in glycerine or a 10 p.c. brine solution.

Bergtheil‡ found the enzyme could be extracted with water after the precipitation of the tannin present in the leaf by means of hide powder, and that such a solution, rendered sterile by means of chloroform, retained its activity for some time.

Bloxam found he was unable to confirm this latter author's work, but he succeeded in obtaining the insoluble enzyme of Beijerinck.

In the final summary of the report Mr. Bloxam makes several suggestions for the continuation of the work both in India and in England. He offers a considerable amount of criticism on the methods of analysis in use in India, and concludes that owing to imperfections in these, the percentage of indigotin in crude cake indigo and in indigo at stages of the manufacture is being considerably overstated. He considers also that the percentage of the leaf present in the plant is really higher than is supposed, and that the colour yielding power of the leaf has been greatly underestimated.

The result is, as has been stated above, that the efficiency of Mahai has, in the author's opinion, been very considerably over-estimated.

How far these criticisms are justified is difficult to say, but it appears necessary to obtain further confirmatory evidence on (1) the factor to be used in the estimation of indigotin by means of potassium permanganate, and the influence of concentration on the results of this analysis; (2) the average percentage of leaf in the plant as used by the indigo maker; and (3) the relationship between the persulphate method of analysis used in establishing the efficiency factor of 85 p. c. and the isatin process on which this criticism is based, before it can be said that the

* Proc. K: Akad: Wetensch: 1900, 2,512.

† Loc. cit., 1899, 2·344.

‡ J. C. S., 1904, 85-870.

question of the efficiency of the present methods of manufacturing indigo has been finally settled, or the possibilities of improvement clearly defined.

In the preface to the report there is a lengthy quotation from an interesting lecture delivered by Professor Meldola to the Society of Arts in 1901, and which was entitled "the Synthesis of Indigo." In this lecture the planter has been severely criticised in no measured terms for what is termed his criminal negligence. How far the unfortunate planter is to blame is difficult to say—the members of this industry are men whose interests and knowledge are chiefly centred in the agricultural side of their work, and it seems most unlikely that they were in a position to realise the danger to be faced from synthetic indigo until this was actually on the market and in competition with their own product.

The reports issued from Pemberandah, Dalsinghserai, Sirseah and from Leeds, voice the efforts which have been made both by the members of the planting community and by the Indian Government to place this industry on a firm scientific foundation.

A quotation is given in the report from the *Manchester Guardian* of the 4th September 1907, showing how in the previous year Germany had exported artificial indigo to the value of 31·6 million marks as against 25·7 million marks in 1905, 21·7 million marks in 1904 and 7·6 million marks in 1898. In 1895 Germany imported natural indigo to a value of 21·5 million marks, and this had sunk to 8·3 million marks in 1898, while in 1906 only 800,000 marks worth were imported.

It can be readily understood, then, that during the last few years the industry has not been in the financial position to invest in any doubtful scheme of improvement or even in one which involved the outlay of much capital—the results of Rawson's investigation in India showed a possibility of improvement in the methods of manufacture to the extent of 30 to 50 p. c. by the use of new machinery and improved methods of working, but only a limited number of indigo makers were in a position to avail themselves of this knowledge.

Time after time the English manufacturer has received warnings from the scientist that unless he was prepared at some personal inconvenience and outlay of capital to introduce scientific order in place of his older empirical methods of working, he would ultimately have to give place to competitors who are availing themselves of the resources of science. The whole English world of industry is full of such instances, and it is now becoming generally recognised that there is no subject of greater importance to statesmen and to the British public than the placing of English industries on a sound scientific basis.

We have in indigo a remarkable instance of a venerable industry ousted from the market and starved to death by the results of years of patient work on the part of the German chemists.

The material from which the synthetic indigo is at present manufactured is a coal-tar by-product, and the fact that the source is such is one of the main reasons for the cheapness of the final product. With the improvement of gas manufacture by new and cheaper methods, and with the enhanced value of what have in the past been regarded as waste products, it is possible to conceive that the most economical method of indigo production may ultimately prove to be from the plant, and there is no reason at present to suppose that this should not ultimately prove to be the case.

It behoves those interested in the industry, then, to make every effort to place it on a firm scientific foundation: foundation built on the possession of perfect knowledge; and to this end we trust that all the workers in this branch of scientific enquiry may receive every help and support in their attempt to reclaim at least one portion of Britain's commercial supremacy.

NOTES.

INDIAN DRY FARMING.—*Recently much has been heard of* American Dry Farming, and large tracts in the South-Western States of U. S. A. which formerly were considered to be too deficient in rainfall to have any agricultural value are now by the proper conservation of moisture made to yield fair crops. The principle is not, however, new and can be seen in the ordinary agricultural practice in many parts of India.

A very interesting and an absolutely scientifically correct adoption of the principle is exemplified in the 'bosi' and 'sailabi' cultivation of Upper Sind. The conditions here in most of the higher lands are an unlimited supply of flow water for a short time, sometimes only 10 days to 2 weeks in mid-summer during the rise of the river Indus. With this water and the help of a little lift irrigation some kharif crops can easily be grown, but a more difficult problem is the production of 'rabi' crops such as wheat and oil-seeds.

The cultivator, however, taught by ages of experience, probably long before America was even discovered, first gets his land flooded and keeps the water on as long as he can by means of small bunds. As soon as the land dries so as to permit bullocks on it, it is carefully ploughed until a fine "tilth" is produced. Thereafter the ground is gone over with a heavy log and the soil carefully consolidated. This corresponds to the American sub-soil packer. A final light ploughing may then be given. The ground will be left till sowing time in October or November or later, and sown by a small drill consisting of a tube fixed to a plough. This does not turn up the soil and so the minimum of evaporation is secured.

On good retentive soil a fine crop can be raised without any further moisture being received, either irrigation water or rainfall, though on poorer soils the crops may be helped out by several applications of well water.—(G. S. HENDERSON.)

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NOTE ON TAPIOCA.—The usual practice of sun-drying tapioca in this country is to remove the skin first, then cut it into thin slices and expose the slices to the sun for 5 or 6 days consecutively until they are quite dry. This method is quite sufficient for the preservation of the root, and for the removal of all the bitter stuffs, if there are any. Boiling before sun-drying is not practised here and is, I think, not essential.

Removal of the skin of the root before cutting it is, in my opinion, advantageous. It must be remembered that the skin consists of an inner and an outer layer. It is enough if at least the outer layer is removed. If it is not done, drying will be more difficult, and will require a longer time. Also there is the danger of the earth that sticks to the outer surface of the root getting mixed up with the cut slices unless special care is taken to wash all roots thoroughly before cutting them. Thorough washing is rather difficult and tedious, and so it is better simply to remove the skin. The extra expenses to be incurred for this will not be much, and whatever is spent can certainly be realised in the price.

Tapioca is a cheap and nutritious food which will serve the people well, especially in times of famine. It has been in Travancore for the last 30 or 40 years, I think. It is very widely cultivated at present and is the staple food of many thousands of poor people.—(N. KUNJAN PILLAI.)

***

TOBACCO GROWING IN HALLA TALUKA, SIND.—The cultivation of tobacco at several places in the Halla Taluka of Hyderabad District (Sind) presents several points of interest. The best land is found in patches and is practically all in the hands of "Bania" cultivators who rent it from the Mahomedan owners and zemindars at an annual rent of from Rs. 8 to Rs. 10 per acre. This

land occurs in the courses of old Indus branches or canals and is generally fine alluvium.

Persian tobacco is the variety chiefly grown.

The following notes are from the report of a farm probationer sent to investigate the typical tobacco areas.

Preparation of soil and rotation.—The cultivators believe that if tobacco is rotated with other crops, yield and quality are unfavourably affected. Consequently on the typical areas, tobacco is grown year after year. The preparatory tillage is thorough and is a great contrast to ordinary Sind cultivation. After a good tilth is obtained, the land is thrown into ridges from 26 inches to 30 inches apart, and the ridges are then flattened down on the top. The preparatory cultivation begins when irrigation water is plentiful with the Indus flood.

Manuring.—Large applications are given and 200 donkey loads per acre is common. Goat manure is in all cases preferred, and this is carefully saved and generally commands a high price.

Seed-beds.—For this purpose sheltered land is selected to protect the seedlings from the hot winds in May and June. The soil is well prepared and ridged with narrow ridges. The seed is sown in these seed-beds, when water is available generally in the end of May or beginning of June. It is mixed with sand or ashes and sown on both sides of the narrow ridges. The beds are well irrigated in the furrows. The seedlings are transplanted when 5 inches to 6 inches high or from 40 to 50 days after sowing.

Transplantation.—In the beginning of July, the fields are ready for transplantation, and the seedlings are removed in baskets with moist earth round them. They are planted on both sides of the ridges alternately, not opposite each other, about 1 foot apart; while young, they are watered frequently, but care is taken that the water runs along the furrow but does not touch the plants. The irrigation is continued for about three months.

Hoeing and topping.—Until the leaves of the plants spread out considerably, weeds are kept down by frequent hoeing with the "kodars." The plants are topped just before flowering.

about three inches of the leading shoot being cut off. This is usually done about six weeks after transplantation. The leaves are thus strengthened, and the plants are prevented from running to stem. They are generally allowed to reach a height of between 3 feet and 4 feet. Among careful cultivators subsidiary shoots from the lower portion of the stem are picked off every week. This helps the development of the main leaves.

Harvest.—The crop is cut in October, generally in the early morning while the dew is on the plants, by stripping off the leaves as they mature. These leaves are spread on a threshing floor in the sun for a couple of weeks. They are then collected and put in small heaps for a few days till quite dry and then covered with mats and straw and pressed down by stones or otherwise. They are fermented in this way for two weeks when they are ready for market.

The stems after the leaves are cut send out flower stalks, and these produce seed which is gathered for the next year's crop.

Outturn.—A good crop on the lands above referred to is about 20 maunds (of 81 lbs.) per acre of cured leaf while 25 maunds is considered a "bumper" crop. The wholesale price is usually about Rs. 10-12-0 per maund.—(G. S. HENDERSON.)

* * *

THE CULTIVATION OF TURMERIC ON THE FOOT-HILLS OF TOUNGOO, BURMA.—The watershed separating the Sittang from the Salween in Burma is succeeded beyond its western declivities by a series of forest-clad hills and dales commonly known as the "foot-hills" of the range. This tract is intersected by winding streams whose waters are clear in the dry months of the year. In the rains, the waters of these streams carry a good deal of silt which fertilises the cultivated lands of the valleys of this region.

The light-free sandy loams overlying the reddish and yellowish sub-soils of the Toungoo District in Burma are preferred by the Shans for the cultivation of turmeric and most other crops. The humid atmosphere of these parts favours the growth of the ordinary crops.

Turmeric and other crops of the same order grow luxuriantly in shady spots.

Wild turmeric and ginger are indigenous in ever-green forests of Burma. The economic uses of these plants are few and local. The leaf shoots, stems and root stocks of the pungent and fragrant varieties enter into the varied diet of the Shans. Some varieties are only used medicinally.

The cultivated kinds of these two crops are grown by the Shans with care separately. A mixture of other crops is usually grown.

The following is a brief description of the method of growing turmeric by the Shans :—Rhizomes of the plant are selected at harvest in December—January for planting in the following season. They are stored under soil and are kept there until the planting season, April—May. The plant is practically dormant in the season intervening between harvest and planting-time, therefore the buried rhizomes, though sometimes watered, do not send up shoots or suckers. They lie dormant through the rainless months; at planting time they are unearthed and broken up into sets of suitable size.

The crop is sometimes grown on newly cleared land, in which the trees are felled and burnt. The larger logs and stumps that survive the flames are allowed to lie upon the land. When the South-West monsoon rains set in, holes from three to six inches in breadth and depth, are dug uniformly with a narrow hoe, a foot or fifteen inches apart. Into each of these pits, one or more sets are planted, covered with earth and pressed down by the foot of the planter. The crop is weeded once or twice, but no other cultivation is given. At harvest, the rhizomes are dug up and stored for seed or prepared for market. Those intended for sale are carried in baskets to the nearest stream and thoroughly washed. They are then boiled in spring water, until they yield to pressure between finger and thumb. After this they are thinly spread out upon mats to dry thoroughly in the sun. They are then sorted into different classes and stored in bamboo baskets for use or sale.

On the foot-hills of Toungoo, three kinds of turmeric frequently occur side by side over one and the same clearing or field. They are :—

(1) San-win-gale, the 'lesser turmeric,'

(2) San-win-gyi, 'the greater turmeric' and

(3) San-win-pyi, the 'white turmeric.'

All three kinds have broad light green leaves that stand from three to five feet above the ground. The rhizomes of the first command the best price; those of the second are comparatively coarse; while those of the third, unlike the root-stocks of the first and second, contain no yellow colouring matter and have, therefore, been named 'white turmeric' by the Shans. The plant is not regarded as turmeric in the sense in which (1) and (2) are, though it too is a species of *curcuma*. Its rhizomes, when cut, show a buff-coloured surface and, when crushed, emit a remarkable odour somewhat resembling that of mangoes. The plants of this kind are pulled by the planter as they are believed to injuriously affect the rhizomes of the better kinds. This variety may, however, have special merits which at present are not understood, but which require investigation.—(A. M. SAWYER.)

* * *

PREPARATION OF VINEGAR FROM SUGARCANE JUICE CARRIED ON AT NAVASARI, BILLIMORA AND BULSAR.—The Mobeds (Parsi Priests) of Navasari (Surat District, Bombay) purchase cane juice from the cultivators of the adjoining villages of At, Ethan Mandir, Kachhiawadi and Jalalpur for the purpose of making vinegar. The crushing season begins generally in the middle of December and lasts up to the middle of March. The juice is sold in tubs; the capacity of each is 52 gallons. The juice is not weighed.

The Mobeds of Billimora and Bulsar get the cane crushed in their presence. Special attention is paid to the following points :—

(*a*) To get concentrated juice containing a large percentage of saccharine matter ;

(*b*) Cane crops which have been recently irrigated are rejected;

(*c*) the top and the butt portions of canes are removed before the canes are crushed.

The Mobeds of Billimora and Bulsar do not sell fresh vinegar, but allow it to remain for some months to make it strong. This vinegar fetches a higher price than that made at Navasari, because at the latter place the arrangements referred to above in connection with the crushing of canes are neglected.

The juice is brought in large vessels to the *Karkhana*, and filled into jars to three-fourths of their capacity. The mouths of the jars are covered with cloth, and are then kept exposed to the sun, so that fermentation may begin. When froth appears on the surface, the jar is opened, and the juice is strained through a piece of cloth into another jar. This straining accelerates the production of vinegar. Straining is required every eighth or tenth day after the froth appears, but later it is required about every fortnight till the juice turns into vinegar. Vinegar is produced usually in 3 to $3\frac{1}{2}$ months; but the time depends upon the quality of the juice and upon the character of the season. The warmer the weather, the quicker the vinegar is produced. If sufficient time is not given, the change from sugar to alcohol and alcohol to vinegar is not complete. The juice containing a large quantity of sugar turns quickest into vinegar by the above described process.

Fifty-two gallons of juice yield from about 32 to 36 gallons of vinegar. Vinegar is occasionally prepared from the scum obtained from the boiled juice of sugarcane. This scum ferments soon and can be quickly converted into vinegar.

Vinegar is sometimes prepared from dates for household use. The extract in water from the dates is allowed to ferment in vats. When fermentation sets in, the liquid is strained through a piece of cloth into another vat. Straining is done every eighth day or so, and in about three months the product becomes vinegar. Vinegar prepared from dates is said to be excellent in flavour and strength, and commands a high price.

The vinegar manufactured at Billimora and Bulsar obtains a high price. A cwt. is usually sold for Rs. 8 or 9. Vinegar prepared at Navasari is sold usually at Rs. 3 per cwt. These rates are wholesale. The retail rates are about Rs. 18 per cwt. for Billimora and Bulsar vinegar and Rs. 6 to 7 per cwt. for Navasari vinegar.

Process of making vinegar.—In making vinegar from cane juice earthen jars are chiefly preferred. There are other means which are not so cheap or desirable.

Jars.—There are two kinds of jars made of *pucca* earthenware, one having a capacity of about 20 gallons and the other of about 45 gallons.

The price of the former is about a rupee and that of the latter from Re. 1-8 to Rs. 2. Before the sugarcane juice is put in, these jars are plastered inside with lac.

Jars can be used for manufacturing high class vinegar for about five years only. Navasari manufactures vinegar on a large scale and exports the whole quantity in hogsheads to Bombay. A small portion is sent to Ahmedabad, Broach, Surat, etc. The vinegar manufactured at Billimora and Bulsar being of good quality is sent inland as far as the Central Provinces, Central India and Northern India.

Uses.—Vinegar is chiefly used in India by Europeans, Parsis, and Mahomedans for pickles, *chatnis* and such like. It is also used by Hindus as a medicine. In high fever it is prescribed as a cold outward application. It is also given to cattle.

Preparation of Vinegar in the Surat District from Palms.—Vinegar is prepared from the juice of palm trees (*Borassus flabellifer*) in the villages of Bhatha in the Chorashi taluka and in the village of Damka of the Olpad taluka. A man is given 30 to 40 trees growing in one place for tapping during the season and is paid at the rate of Rs. 10 a month or a part of the net profit. The Government duty is Re. 1-8 per tree for manufacturing vinegar. In the year 1907-8, about 200 trees were given in each of the talukas for the manufacture of vinegar. The trees when about fifteen years old are ready for tapping, and they live for 60 years.

There are two seasons when the palms begin to throw out flower stalks: (1) about October and (2) about February.

The sap is extracted from the flower stalks. Both the male and the female trees are tapped for their juice. In a male tree the finger-like clusters are first beaten with a stick along their whole length and then tied together; while in the female, the flower stalks are first strongly tied to check their further expansion, and the embryo is crushed. Thin slices are every day cut off from the ends of these stalks for about ten to fifteen days till the sap begins to flow out. When the juice begins to flow, the finger of the male tree and the spike of the female tree must have their points cut every morning and evening. The juice as it oozes out is collected in earthen chatties placed over the stalks in a slanting direction and covered with sheaths of straw. Every morning the chatties are emptied and replaced, the stump cut until the whole is gradually exhausted and cut away. The average yield of a tree per year is calculated to be 60 gallons of juice. The female trees yield much less.

The tapping operation, though slack in the rainy season, goes on for ten months of the year and gives employment to the professional workers almost all the year round. A tree continues to yield for four or five months. The juice extracted from the palm trees is believed to be purer and cleaner than that from the sugarcane.

Preparation.—Vats are filled to three-fourths of their capacity with juice and their mouths covered with cloth. They are put in the sun for fermentation, which sets in in about six to eight days, and when the froth appears on the surface, the stuff is strained into another vat. Straining is done every sixth or eighth day, and in about a month and a half the product becomes vinegar. The period required for fermentation depends on the temperature prevailing at the time of the year. The vinegar is put in a wooden cask and sold. The wholesale rate of vinegar prepared from toddy is about Rs. 2-8-0, and the retail rate about Rs. 5 per cwt. This vinegar is exported to Bombay, Ahmedabad. Baroda, Ajmere, etc. Vinegar prepared from palms does not

generally keep well for more than two years as it is not strong. It has a dirty white colour, whilst that prepared from sugarcane juice has a reddish colour.

The total quantity of vinegar prepared in the Chorashi taluka was 9,861 gallons in the year 1907-8, and that prepared in the Olpad taluka was 3,196 gallons only as the work of the latter depôt lasted only for five months. One hundred gallons of toddy palm juice give about 75 gallons of vinegar. Vinegar is known in Gujrati and Hindustani as *Sarka*.—(D. P. MANKAD.)

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THE SINGHARA NUT.—Singhara *(Trapa bispinosa)* is a herb found floating on the surface of tanks, lakes and pools throughout India and Ceylon and is commonly found in the Madras Presidency. The nut of this plant is used as a food in Kashmir and the north of India, but in Madras it is practically unknown, although some of the poorer classes may occasionally be seen eating the boiled kernel. A sample of the flour prepared from the kernel gave the following analysis:—

Moisture	10·20	per cent.
Ash	3·22	,,
Crude fibre	1·53	,,
Oil and extractives	·60	,,
Reducing sugars..	Heavy	trace.
Other sugars	2·52	per cent.
Starch	72·44	,,
Proteids (N x 6·25)	8·78	,,
	99·29	
P_2O_5	·846	
K_2O	·931	
NA_2O	·334	
Nitrogen	1·404	

The flour was found to be devoid of gluten, and therefore could not compare with wheat flour from the point of view of bread-making, but it would answer the purposes of much native cookery.

The proteid content is about equal to buckwheat flour, is higher than barley and Indian-corn flours and is lower than

wheat and rye flours. The crude fibre value is high, but this is due to the sample containing coarse substances derived from the integument of the nut and which would be removed by the simplest "bolting" process.

The starch consists of separate ellipsoidal grains with a central hilum, which rarely forms a cleft. The polarization crosses are very distinct and a brilliant display of colour is produced by a selenite plate. The size varies from 8 to 40 μ, the common size being about 34 μ.

According to the *Dictionary of Economic Products*, the plant is largely cultivated in Kashmir and the north of India, and in the former place forms the staple food of 30,000 people for at least several months of the year.

The kernel is rich in starch, resembles the chestnut in flavour, and can either be eaten raw or cooked.

The cultivation is not attended with any great difficulty. Towards the end of January the seeds are scattered on the surface of the water, where there is no chance of their drying up before the rains, and then pressed into the mud where they soon begin to shoot. In June any excess is thinned out and transplanted. In October the nut forms below water and the fruit is gathered in November and December.

In view of the fact that the nut is nutritious and is common throughout the country, its cultivation may be recommended as forming a standby in bad seasons when crops might altogether fail.—(W. H. HARRISON.)

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FISHING INDUSTRY IN MADRAS.—Sir F. A. Nicholson, K.C.I.E., I.C.S., whose "Note on Agriculture in Japan" was reviewed at some length in a previous number of this Journal (*A. J. I.*, Vol. III, Part I), has recently published the final results of his preliminary investigations in regard to the establishment of a Marine Fisheries Experimental Station in the Madras Presidency. "We want to develop," says Sir Frederick, "*gradatim et pari passu*, the fisher folk, the fishing industry, and the fishing trade, by methods which will not necessarily reduce their position

to that of hired labourers under capitalists (European or otherwise)."

The present fishing industry in Madras is almost entirely "inshore" fishing and will not therefore be affected by the investigations which will be concerned with "deep sea" fishing beyond the three or four-mile limit. The principal object of the investigations is to provide cheap food to the "75 to 90 per cent. of the population who will always eat animal food if they can get it, but who cannot afford more than 2 annas or so per pound for good solid nutriment, and even less for ordinary fish or flesh." As it is, a very large proportion of the fish that is exposed in markets is "tainted" and unwholesome. The enquiries of the Experiment Station will, therefore, among other things, be directed to the preservation of fish, not by expensive European processes, but by indigenous methods, such as preparation with tamarind, turmeric and red pepper. The question of rapid transit will also receive consideration.

Several useful industries connected with the by-products of fish (oils obtained from the blubber, the skins, shells, etc.) are successfully carried on in America and represent in value an annual outturn of over 10 million dollars. It is natural that the Experiment Station should also concern itself with these, and Sir Frederick Nicholson recommends a set of tools and plant for the manufacture of pearl buttons. His observations in regard to this industry are of interest. "It is not generally known," he writes, "that pearl-shell, a by-product of the pearl fisheries, is exported from Ceylon in enormous quantities every year; in 1906 the export was 13,800 cwt., of which Germany took more than half, Japan about 1,150 cwt., and Great Britain only 922 cwt.; in ten months of 1907 the exports were 10,575 cwt., of which Germany took 7,002. These are for common pearl button-making, and of course only perfect shells are worth sending; allowing for breakage and useless portions, possibly half of the weight of the shell is actually utilised for button-making, so that freight and other charges are paid on a mass of useless material. The shells are sent in bags or wooden cases; if sent in

bags, the packing cost is less than if in cases, but breakage is considerable. But it actually pays to send pearl oyster shell, say, to Germany and the United States of America, to pay cost of packing, freight, breakage, agency charges, etc., and to work them with expensive labour into cheap pearl buttons which are again sent out here for sale. This is one of the absurdities or scandals of Indian industry: there is little enterprise, knowledge or capital needed to start this business in India (or Ceylon) and to save all the intermediate costs, while promoting a new industry which ought not merely to supply India, but Europe, with buttons. In the case of India, a supply of shell, when our own supplies are exhausted, could be brought over to Tuticorin, etc., by native craft at minimum cost, especially by Kilakariai boats returning from pearl fishing, and it is to be noted that whereas only perfect shell can be sent to Europe, there are millions of less perfect or partly broken shells, which are perfectly available for working up on the spot."—(C. S. RAGHUNATHA RAO.)

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THE INDIAN PENS.—Pens in common use in the vernacular schools of the Bombay Presidency are made from the culms of (1) *Andropogon halepensis*, Brot., which are white, soft and solid. The plant which is very cheap is abundant on the banks of the Deccan rivers in shady places and is also found in large quantities on moist lands in the Konkan and Gujrat.

The culm of another grass which is black and hollow is also sold in the bazaars for making pens. Its "pith" being very scanty comes out in a string from the centre. The end is cut in the slanting direction. Enquiry has shown that this material is not indigenous but an exotic from China.

Another kind—hollow, hard and more durable than the above two—seems to be produced from a species of bamboo and is also an exotic from China. It is often used by the Bombay merchants. In Gujrat and Kathiawar people also use the culms of *Pharagmites karka*, Trin., locally known as *Achhni* (Gujrati).

Pens are also made in the Haveri taluka of the Dharwar District from the midrib of the leaflets of *Caryota urens*, Jacq., locally known as *Bagani galagu* (Canarese).

The pen fern from the Darjeeling District in Bengal is *Gleichenia linearis*, Bedd.

Pens are sometimes made of thin jowari stalks when reeds are not easily available. Being soft and pithy they soon wear away.

Pens are also made of porcupine quills. The use of the quill feathers of birds which is slowly disappearing is an old indigenous practice.—(G. B. Patvardhan.)

* * *

Annatto.—Annatto is employed as a dye for calico, silk, wool, skins, feather, ivory and bone and in colouring butter and cheese. It produces a fast colour of both yellow and red tints. The plant (*Bixa Orellana*) is a native of West Indies and other parts of tropical America.

It is a shrub or small tree of very branching habit of growth and attains a height of 8 to 12 feet. It is a hardy plant and fruits very freely in the plains of India in any ordinary soil and climate.

The fruit is a capsule which, when ripe, splits into two valves, on the inside of which are attached seeds covered with a thin coating of reddish waxy pulp. This waxy substance contains the colouring matter known as Annatto.

The dye is extensively used for colouring butter and cheese in nearly all countries, for which purpose in India the seeds are ground to a fine powder and soaked in pure olive, sessamum or safflower oil. The extract is then strained through fine muslins.

The plant is propagated from seed which should be sown in a shaded nursery. When the seedlings are about four months old, at which time they should be 6 to 8 inches high, they should be transplanted about 12 feet apart, if the soil is good. Pits should be dug out to a depth and diameter of 18 inches for each seedling.

Fair crops may be expected in three or four years, but it takes longer to get a fully established plantation.

In India the plant has been grown chiefly in Government gardens. It is a plant of considerable economic value and should be more widely cultivated.

The seeds, when ripe, should be extracted from the capsules and dried in the sun. They may then be steeped in very hot water. By stirring, the waxy testa is then washed off from each seed. After some days the whole mass should be strained. The liquid should be allowed to ferment for a week and then the dye matter settles. The clear water should then be poured off, and the dye dried in shallow pans. When the substance is semi-hard, it may be moulded into rolls, wrapped in Banana leaves, and then becomes the ordinary Annatto of commerce.

In Jamaica, Annatto is an important export, almost entirely produced by the peasant class. These exports are increasing and go chiefly to the United States.—(EDITOR.)

* * *

INDIAN SUGAR INDUSTRY.—The Bombay Department of Agriculture have lately issued a leaflet about the relative profits of making *Gur* (crude sugar) and of making refined sugar by the Hadi process. It shows that in the present conditions prevailing in the Poona District it pays far better to make *Gur* than to manufacture sugar. The initial cost and recurring expenses for upkeep of the plant required in Bombay for *Gur*-making is much less than that required for the Hadi process. The net profit per acre of cane made into *Gur* was also found to be larger. The reason is that *Gur* in Bombay commands in most seasons a high market rate because it is suitable for certain kinds of Indian sweetmeats and cookery.—(EDITOR.)

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NEW PLOUGH FOR SIND.—On the Mirpurkhas Farm the following form of wooden plough has been found to do very good work. It is a slight modification of the indigenous wooden plough of Egypt. With perennial irrigation, where the land

can always be softened by water, it is a most efficient implement. Along with the leveller or "ghasabiah" it forms practically the whole stock-in-trade of the Egyptian cultivator. It has there held its place in the estimation of the cultivator against repeated attempts to introduce iron ploughs. The broad share deals effectively with weeds. The sharp-pointed Sindhi plough, on the contrary, is very apt to miss a considerable number of these, and in particular often fails to pull up the very troublesome creeping stems of "kull" and other plants.

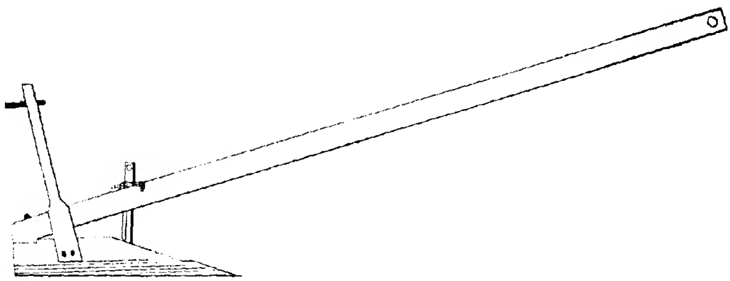

FIG. 4.

Construction.—The pole is made of jarrah or any long grained wood and should be about 11 feet long and 4 inches broad and 2½ inches thick. The body is of babul wood, about 3 feet 6 inches long. The body and pole are dove-tailed into each other and fastened by a moveable bolt. The handle is fastened to both ends of the body, leaving the pole free to move on removal of bolt. Half way along the body an iron bar is fastened through the body, and goes through the pole. At the top of the iron are several holes by means of which the angle between body and pole can be regulated. The share is 6½ inches broad and spear-shaped, being fastened to end of body. The total cost of construction, including labour and material, is between Rs. 7 and Rs. 8.

Demonstrations of this implement are being arranged to be held in each Taluka town, when a sufficient supply of implements has been made.

Ridging.—For ridging up land a piece of wood of the following shape is inserted behind the iron bar :—

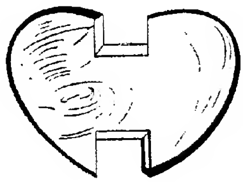

FIG. 5.

General Use.—The cost of ridging with the plough is very considerably cheaper than the same work done by hand with the "kodar." With a couple of ploughings, any land should be in sufficiently good tilth for ridging up. It is essential for the proper growth of Egyptian cotton and all other crops that the land must be in good tilth and properly cultivated, and this can be done probably better by means of this plough, than by employing an expensive English iron one. It has an advantage over the latter, in that the cultivator takes to it naturally. He has no difficulty in holding it, as he has with the two-handled plough. On the other hand, there are several makes of light one-handled iron ploughs having wooden poles. These have, however, been found quite unsuitable for this class or hard soil, it being almost impossible to keep them in the ground.

In comparison with the Sindhi plough, though slightly heavier in draught, it will do a half more work and go a couple of inches deeper. The dimensions given above were adopted for ploughs worked by cattle of the Cutchi or Guzerati type. The sizes may, however, be varied to suit smaller cattle.—(G. S. HENDERSON.)

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THE BENGAL AGRICULTURAL COLLEGE.—On Monday, August 17th, His Honour Sir Andrew Fraser, Lieutenant-Governor of Bengal, laid the foundation-stone of the Bengal Agricultural College. The occasion was a noteworthy one, marking as it does a further advance in the policy of agricultural development

inaugurated under Lord Curzon's régime and in the scheme of Provincial Colleges for agricultural education and research, throughout India.

The Bengal College is not the furthest advanced of these, although at the time of the foundation-stone ceremony it was well above plinth level. It is, however, hoped that it will soon be complete for the reception of students.

Meanwhile the European staff, consisting of the Principal of the College who will have charge of the agricultural section and will control the general work of the College, is on the spot. The Economic Botanist and the Agricultural Chemist are also already at work in temporary laboratories, and doubtless will take in hand the planning and fitting of their permanent laboratories and such preliminary investigations in their respective lines of work as may be possible. The Principal is gaining local knowledge as to the ways and means of practical agriculture in Bengal and is laying out his College farm.

The College is charmingly situated on an elevated site at Sabaur, about five miles from Bhagalpur. Three hundred acres of land have been acquired, 170 of which will be devoted to farm purposes, and the remainder for the College and other necessary buildings and for a garden of plants of economic value in Bengal.

The East Indian Railway runs through the property which is thus extremely easy of access.

As an experimental and demonstration farm, the site selected leaves little to be desired, providing as it does conditions of soil and climate under which almost any crop typical of the plains portion of the province may be grown with average rainfall helped by irrigation from wells which can be profitably arranged for.

The function of the College will be similar to that of the other provincial institutions throughout the country. It will provide a centre where the many scientific problems affecting agriculture in Bengal may be investigated and from which the practical results of such investigations may be disseminated amongst the people, whilst, at the same time, providing that grounding in general agricultural education and the cultivation of

the scientific habit of mind, which are so essential to a proper appreciation and utilisation of such knowledge.

It has been wisely recognised by Government that the problem of agricultural improvement as it affects the whole of India is too vast a one to be dealt with at any one institution, however fully staffed and equipped it might be. Apart from the educational aspect of the matter, which can obviously only be dealt with under local conditions, it is in the highest degree advisable that the work of investigation should be carried out all over the country so that problems of local importance may receive adequate treatment. A central institution such as Pusa provides, can then perform the necessary function of co-ordinating the various results obtained and advising the application of knowledge gained in one quarter elsewhere, whilst simultaneously performing its main function of conducting research on problems of general application to India. The relative position which should exist between the provincial institutions and the central one was aptly expressed by Mr. W. R Gourlay, the Bengal Director of Agriculture, in the speech in which he opened the proceedings at Sabaur. In the course of explaining how it was found that although Pusa was situated in Bengal it would not meet the needs of the province either in the matter of research or of education, he said :—" It was recognised that Pusa must be an international institution whose main object is research, and that it would be unwise to hamper the Imperial experts with the duty of elementary teaching. Their undivided attention must be given to solving the greater problems of agriculture so far as they affect the whole of India, and whatever teaching is undertaken by them must be of an advanced nature with a view to training the best graduates of the Provincial Colleges to hold the highest positions in the Indian Agricultural Service, so that in time India will require few experts from outside."

It is hoped to attract the sons and agents of the Zamindars and the members of the hereditary cultivating classes of Bengal to the college at Sabaur and to work through them to the ryot and to all sections of the agricultural community. Again, in

quote Mr. Gourlay: "An Agricultural Department in India differs from a similar organisation in Western countries, in that the latter is the outcome of the spontaneous demand of the cultivators, while the former has been created from above, and the gap between the department and the people to benefit whom it has been created has to be bridged. The Agricultural College is the main arch of this bridge and the Agricultural Associations are its buttresses. The natural sequence of the department will first be research and experiment and then demonstration to the people; while research and experiment are being carried on, the training of the men to carry the results to the people will be done at the College, and we hope to train in this institution men who will go forth to every district of the province equipped with a scientific and practical knowledge of agriculture. These men will form the centre from which the achievements of the departments for the benefit of the cultivator will be spread far and wide throughout the land. We look forward in time to having one such expert in every sub-division surrounded by an agricultural association of all the best cultivators of the country."

If these hopes are realised, then the foundation of the Agricultural College at Sabaur will indeed "prove a land-mark in the advance of the welfare of the cultivator in Bengal."—(C. J. Bergtheil.)

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Cardamom Cultivation in South Mysore.—Mr. D. J. Evers is the writer of an interesting article on this subject in the November number of the *Indian Forester*. Various kinds grow luxuriantly, particularly in moist places in the Forest ghats of the Mansarabad and Belar Taluka of the Hassan District. The plant is said not to thrive on Southern and Western exposures. It comes up spontaneously in the ghat forests when light is admitted by the felling of some large trees. The general belief is that the seed which induces such growth is disseminated by monkeys and rats. The cultivation by some planters is considerable; nearly all coffee estates have fair-sized areas under this crop on partially cleared forest land.

There are two methods of cultivation : (*a*) the method adopted by Brook-Mockett and Middleton, the two largest planters, and (*b*) the Coorg system. In the former the forest is thinned out to admit sufficient light, and nursery-raised seedlings are used to plant out the cleared area. The crop begins to yield in the third or fourth year and is in full bearing in the fifth or sixth. Irrigation, if available, is useful at some seasons ; weeding is required. In the Coorg system, small detached areas on which the plant has come up naturally are carefully selected. In February-March, small trees, two to three feet in girth, and brushwood are cleared. The forest leaf canopy should not be too dense, and it may be necessary to fell one or two large trees across each plot. The seedlings make their appearance soon after the first burst of the monsoon and by the close are three or four inches high. At the beginning of the following monsoon, they are thinned out where overcrowded and vacant spaces are stocked. The plants yield in the fourth or fifth year according to the richness of the soil. They continue to produce good crops till the fourteenth year, when they begin to decline and die. Then the soil has to be renovated by felling one or two big trees across each small plot. The Coorg system does least harm in the clearing of valuable trees.

There are two methods of drying the produce, (*a*) spreading it on mats or in trays and exposing it to the sun, and (*b*) drying it over a slow fire. The oven is a long, brick and mud structure, the roof of which is either flat and formed of zinc sheeting or a hollowed-out trough. The fruit is spread over the oven until sufficiently dry. After the fruit is dried, the stalks are cut off and the produce is ready for sale. Cardamom is largely sold locally and in winter a class of people called *Beries*, from South Canara, buy up large quantities. The Hindus pickle the tender green fruit : when dry, it is much used in confectionery. In Coorg, the Forest Department cultivate cardamom.—(EDITOR.)

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OPIUM IN PERSIA.—The cultivation of opium in Persia has, within the last twenty years, spread from the Provinces of Jezd,

Kerman and Ispahan over the whole country, and now occupies a considerable area which was formerly devoted to wheat. There is an increased consumption among 20 per cent. of the population. The crude opium is collected from the capsules in the common Indian way.

For home consumption as well as for export, it is boiled down by slow fire and extensively mixed with various ingredients which include grape juice, wild rue (*Ruta sylvistris*) and sarcocolla, a resin of *Panæ mucronata*.

The export trade is increasing and the whole trade is very considerable, but no definite statistics are available.—(EDITOR.)

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POPPY CULTIVATION IN AFGHANISTAN.—Poppy has apparently begun to be extensively cultivated in Afghanistan. In 1906-7, Afghan opium was first imported into the Punjab through Peshawar to the extent of 125 cwt. The quality is reported to suit the taste of consumers, and to some extent this opium takes the place of Malwa opium. The traders who have dealt hitherto in Malwa opium have probably found in Afghan opium a good paying article of which they can push the sale; and the imposition of adequate taxation upon it may be a matter of importance before a large trade develops.—(EDITOR.)

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WELL-BORING.—Mr. Alfred Chatterton, Director of Industries, Madras, and author of the well-known work on *Lift Irrigation*, has sent to the Press the following interesting note on the subject of well-boring:—

"When the construction of a well is undertaken, there is almost always some uncertainty regarding the volume of the water-supply that will be obtained. This is due to the fact that what lies below the surface of the ground is always more or less a matter of conjecture. In some cases our knowledge of the subsoil is sufficient to render the risks of well-sinking of no practical importance, but in the majority of cases it is otherwise, and a preliminary examination of the ground, if it can be made at

comparatively small expense, is of distinct advantage. This can be done by boring or jumping a hole of small diameter to such depth as is necessary with the aid of specially constructed tools. The material removed from the hole affords information as to the nature of the strata through which the well will pass, and this information, studied in the light of the experience which has accumulated from the sinking of many thousands of wells, enables us to form a fairly accurate idea as to the quantity of the water likely to be obtained. Where the subsoil is soft or sandy, the hole must be provided with an iron liner to prevent it from filling up as fast as it is made, but where the hole is in stiff clay or rock, the boring work can be done without any such artificial support.

"In a brief note it is impossible to describe in detail the tools employed, but it is not difficult to explain the principle upon which they work. Just as a hole is bored in wood by means of an auger or bit, so through the soft strata of alluvial deposits holes can be driven by similar tools of much larger dimensions. As the auger consists of a handle, a shank and the cutting edge, so the boring tools are similarly constructed. Various types of auger head are used and these can be screwed to steel rods which are usually 10 feet long and as many as are necessary are employed to reach from the surface of the ground to the bottom of the bore hole. At the top there is a swivel head by which the rods can be lifted and the handle of the auger is formed by clamping iron levers to the boring rod at a convenient height above the ground, so that men by walking round in a circle can rotate the auger. When the material to be bored through is fairly stiff, the auger takes the form of a worm or an open shell, and from time to time it has to be lifted from the hole to remove the clay which has gradually worked into it. When the soil is of a loose character, the auger has to be fitted with a shell above to hold the material removed by the cutting edge, otherwise it will fall back into the hole whilst lifting the auger to clean it. These shell augers are fitted with various shapes of cutting edges depending upon the nature of the material to be removed, which

may vary from fine sand to soft sandstone. When hard rock has to be pierced, rotary tools worked by hand are not effective, as the speed of working is too slow and recourse must be had to the percussive action of variously shaped chisels for the breaking of the rock. The chisel is attached to the boring rods and a heavy blow is given by lifting them a few inches and allowing them to drop. Care must be taken to slowly turn the boring rods so that each blow of the chisel falls on a different diameter in the bore-hole. When the chisel has pulverized a sufficient quantity of rock, it is withdrawn from the hole and a plain shell lowered which collects the mud when it is rapidly jerked up and down in the water at the bottom of the hole. To work a set of boring tools it is necessary to have a derrick which may be conveniently made of 4 casuarina poles about 25 feet long. At the top of the derrick is fastened a pulley over which the lifting rope passes from the swivel head to the winch. This latter may be attached to two legs of the derrick and should have a lifting capacity of at least 2 tons. Besides the chisels and augers there are a great variety of tools which can be attached to the boring rods, most of which are ingenious devices for removing broken tools from the hole.

"As the hole proceeds through soft material, lining tubes must descend with it, and this is usually effected by rotating them, their own weight being sufficient to make them descend. If the pipes stick badly, a suitable cap must be placed on the top and the methods commonly employed in pile driving resorted to. If the lining tube has to pass through a layer of stiff clay, the work is often facilitated by rymering the hole bored out by the auger to a larger size. If it is not intended to bore holes to a greater depth than 50 feet, a set of tools working a 3-inch liner will be a convenient size to employ, but if the holes are to run to a depth of 100 feet or more, the diameter of the lining tube should be at least 4 inches.

"Where it is known that artesian or sub-artesian water exists, it is necessary to use pipes of much larger diameter if it is desired to obtain an abundant supply of water.

"Well-boring has been developed in the French territory of Pondicherry much more extensively than in any part of the Madras Presidency, and it is possible to procure sets of boring tools from the blacksmiths in Pondicherry at very reasonable rates. They do not, however, supply the tools necessary for withdrawing the lining pipes and the sets are therefore not convenient for exploratory work, as in such work the lining tubes are usually removed from the holes as soon as the necessary information has been obtained. Messrs. Burn and Co., of Howrah, supply suitable sets of tools. A set with lining tubes to bore a hole to a depth of 50 feet costs about Rs. 700 delivered in Madras, whilst a 4-inches set of tools with lining pipes costs about Rs. 1,100. Considerable experience is required to make satisfactory use of a set of boring tools, and difficulties and obstructions frequently occur which can only be dealt with by men experienced in such work. In boring, the tools are subjected to rough usage and repairs are frequently found necessary. It is therefore desirable to have a fair number of duplicate parts, so that the work of boring need not be stopped while repairs are being effected.

"The cost of boring varies considerably, depending not only upon the diameter of the borehole and its depth, but also upon the character of the soils or rocks pierced. In the alluvial deposits along the Coast in the Chingleput District where some 400 boreholes have been put down, the average cost for a 3-inch borehole is about 4 annas a foot up to a depth of 20 feet, thence on to 40 feet it costs 6 annas a foot, and beyond that up to 60 feet, 12 annas a foot; from 60 to 70 feet the cost is Re. 1 a foot and from 70 to 80 feet Rs. 1-4-0 a foot. Beyond this depth only a few borings have been made and the cost of the work done has varied considerably. These rates, it should be pointed out, do not include the cost of carrying the tools from one place to another. This is a small item when many holes are to be put down in one neighbourhood, but becomes of importance when the tools have to be carried a long distance to bore a single hole.

"The principal sources from which subterranean water can be derived are beds of sand and rock which is highly fissured or partially decomposed. By putting down a borehole, information on these points can be obtained and the exact depth at which the water-bearing strata is met with can be easily determined, or its absence definitely ascertained. Sometimes in fissures the water exists under pressure, and a borehole from the bottom of an existing well tapping a fissure will often deliver considerable quantities of water into the well from which it can be removed either by baling or by pumping. Along certain parts of the Coast, beds of sand are found enclosed between impervious beds of clay. Some of these are of considerable extent and thickness, and they contain water under pressure. Boreholes penetrating the upper impervious layer enable the water to rise to its static level and, when this is above the ground, flow takes place and the supply is termed artesian. More frequently the static level is below ground level and the water can only be obtained by sinking a well round the borehole to a few feet below the static level. Water will then flow into the well and can be removed by baling or pumping. If the borehole is made sufficiently large, a suction pipe or pump may be put down the hole and the water drawn off by lowering the static level in the borehole itself. Ordinarily, however, borings do not penetrate artesian basins, and the character of the water-supply likely to be derived from sinking a well must be determined by an examination of the materials through which the borehole has passed. Gravels usually yield water most abundantly, then coarse sand, and lastly, fine sand. When the sand is coarse, or the water-supply is derived from gravel, a well of small diameter will generally yield a large quantity of water, but when the sand is very fine, a well of large diameter is required to obtain a large supply of water, and that again is only possible when the bed of sand is of considerable thickness. When the borehole has passed through rock and the chisels have to be used, no very definite information can be gained from an examination of the material brought out of the borehole, but by putting a tube well pump down the borehole, and exhaust-

ing the water we can ascertain the rate of the inflow from the surrounding rock into the borehole under a given pressure. Apart from fissures, this enables a rough estimate to be formed as to the water-yielding capacity of the rock.

"The experience so far gained in the South of India is undoubtedly to the effect that large supplies of water are generally only to be obtained from beds of sand or gravel, but occasionally wells in fissured rock yield an abundant supply of water, whilst percolation wells in porous or decomposed rock seldom yield more than moderate quantities of water. That is to say, they may yield 3,000 or 4,000 gallons of water per hour, but not 10,000 or 12,000. So far the largest supply of water derived from any single well in the South of India is 45,000 gallons per hour. This is not, however, the limit of the capacity of the well, but that of the pump working on it. During the last year or two, oil engines and pumps have been installed in many places to lift water for irrigation, and the size most commonly employed is a 4″ pump which will deliver sufficient water for from 20 to 25 acres. This is equivalent to from 18,000 to 20,000 gallons of water per hour, and although there are few indigenous wells which will yield this supply, it has not been found difficult to obtain it from wells sunk after a preliminary investigation of the ground has been made by the use of boring tools. There is undoubtedly a vast amount of subterranean water which has never yet been made use of, and to locate it definitely boring tools must be used."

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Paper Pulp.—The samples of paper, prepared mainly from megass, exhibited at recent meetings of the Trinidad Agricultural Society, give promise of an important subsidiary industry in connection with cane-growing.

These samples have been made at the Tacarigua Factory by a process of which the Proprietor, Mr. Bert de Lamarre, is the originator.

Various kinds of wrapping paper have since been produced, but the bleaching experiments are still in progress.

It is expected that for every ton of sugar a ton of megass will be available. This works out to an average of about 50,000 tons yearly for this Colony.

Allowing 20 per cent. for moisture and waste, there should be a balance of 40,000 tons of fibrous material suitable for making paper.

Samples of this paper are exhibited at the Victoria Institute. —(BULLETIN No. 60 OF MISCELLANEOUS INFORMATION. TRINIDAD.)

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* *

DATE PALM CULTIVATION.—In February 1908, seven date palms in the Central Jail, Trichinopoly, came into flower, and three of them bore fruit. These palms are the product of Muscat dates. The seeds were sown in pits dug three feet cube and well watered. They germinated in about 20 days. The ground was neither cultivated nor manured. In February 1907 three palms came into flower, two males and one female. For want of artificial fertilisation, the fruit set imperfectly and dropped. In February 1908, these three palms again flowered with four new ones, two males and two females, when Mr. H. C. Sampson, Deputy Director of Agriculture, Madras, showed me how to use the pollen by tying up a branch of male flowers over a female inflorescence. On the two artificially fertilised trees, the fruits set and came to maturity in fairly large quantities; in the third (not artificially fertilised) the fruit set in great profusion, but did not ripen and had no seed. Of the three trees that bore fruit, two were of one variety and bore long golden coloured dates. The third tree bore crimson fruit which turned brown when ripe.

At Boce camp, about one mile from the Central Jail, there are several hundreds of date trees. The dates are the favourite food of the Boces. These palms look strong and healthy even without cultivation and watering; their seeds were not sown, and the stones grew where the Boces had spat them. The Boces left in 1902, and the date palms are now flourishing at the camp. Some of them are well grown enough to flower and are undoubtedly very hardy; inside the Jail none has died.

A curious fungus attacks the leaves, but apparently does no harm : a few trees were attacked and damaged by boring beetles : when the fruit was ripening, ants infested the branches which had to be protected by linen bags.

Stones of both varieties have been collected from the ripe fruit and sown ; the young plants from them now look healthy. Stones of both varieties were sent to the Central Jails at Coimbatore, Vellore and Bellary : and those sent to Vellore are reported by the Superintendent to have germinated.—(R. SHUBRICK.)

REVIEWS.

AGRICULTURAL EDUCATION IN ENGLAND AND WALES.*

THE Minutes of Evidence taken before the Departmental Committee appointed by the Board of Agriculture and Fisheries to enquire into and report upon the existing facilities for affording scientific and technical instruction in England and Wales, which has just been published as a Blue Book extending to over 600 pp., contains a mass of information on almost every branch of agricultural education. The President of the Committee was Lord Reay, formerly Governor of Bombay; in the course of thirty-one sittings held between April 1907 and February 1908, one hundred and thirteen witnesses were examined, and among these were Heads of Universities, Principals and Professors of Agricultural and other Colleges, Experts in the various branches of applied science pertaining to agriculture, Government Officials, and Colonial Representatives. Of these last, two were from India, Mr. H. S. Lawrence, Director of Agriculture, Bombay, and Mr. W. H. Moreland, C.I.E., Director of the Department of Land Records and Agriculture in the United Provinces.

It is impossible to refer, in order, to the various subjects which came up for enquiry or to compress the evidence tendered before the Committee in the course of a brief review. We merely indicate a few salient points in the evidence given by the Indian witnesses, and refer incidentally to the progress of

* Minutes of Evidence taken before the Departmental Committee appointed by the Board of Agriculture and Fisheries to enquire into and report upon the subject of Agricultural Education in England and Wales, and Index. Printed by McCorquodale & Co., Ld., London. Price, 5*s*. 3*d*.

agricultural education in one or two foreign countries about which some interesting information was elicited by the Committee.

Mr. Lawrence was the first Indian witness who was called in, and in the course of his evidence he pointed out, as showing the importance which the Government of India attach to agricultural education, that every officer of the Bombay Civil Service was now required, within the first year of his service, to study the elementary problems of Indian agriculture during a short stay at Poona, and that officers who were appointed as Directors of Agriculture were encouraged to go to England in order to attend some of the courses at the higher agricultural colleges there. The establishment of a readership in tropical agriculture in one or more of the British Universities, he stated, would enable such officers to benefit by their course. This was a suggestion that had emanated from Dr. Barber, the Government Botanist of Madras, and Mr. Lawrence considered it an admirable one, if it was possible to obtain for the readership one with experience of agriculture in a tropical country. Prof. Middleton, Assistant Secretary to the Board of Agriculture and Fisheries, pointed out that the expense of subsidising such a chair would be about three or four hundred pounds. If other tropical countries, such as Ceylon or the West Indies, who would also be benefited by the establishment of the readership, could co-operate and agree to a distribution of the expense, the proposal is certainly within the bounds of practicability. Mr. Lawrence then gave the Committee a brief historical sketch of the constitution of the Imperial and Provincial Departments of Agriculture in India, with detailed information relating to the work carried on in the Bombay Presidency.

Mr. P. J. Mead, Acting Director of Agriculture, Bombay, submitted a few supplementary notes to the Committee, in which he urged, among other things, the desirability of giving to the European experts now in India opportunities of keeping their knowledge up-to-date. If they could periodically be granted "study leave" and could add to their present experience of Indian conditions, a knowledge of the best work done at great

centres of scientific research, their usefulness would, he considered, be greatly increased.

The evidence of Mr. Moreland was mostly in connection with the working of the Co-operative Credit movement in India. The only other subject on which he tendered evidence was in the matter of the control of agricultural education. He stated that its *control* should be entirely under the Agricultural Department, and that the Educational Department should merely advise and assist when necessary. He submitted to the Committee a Memorandum stating the reasons why the Cawnpore Agricultural College was placed under the control of the Agricultural Department.

Perhaps, the most interesting evidence was that given by Professor Middleton. He strongly advocated the study of practice in agriculture before the completion of the course of theoretical study. He stated that what the agricultural student wanted was information on which he could depend, and if provision could be made for what the agricultural student asked for and required, students would be coming forward in increasing numbers to acquire that knowledge so that they may utilise it. He gave detailed information of his own career to illustrate the kind of education which he wished imparted to students. As a boy he was brought up upon a farm, his father having been a tenant farmer. He received his school education in Edinburgh. After leaving school he went almost as a matter of course to a Scotch University. He graduated at the age of 19, and then he went back to farming. His intention was to farm in Scotland. He had occasion to carry out, in connection with the Highland and Agricultural Society, a number of demonstration plots. He became very much interested in this type of work, and he saw that if he was to get any direct advantage from science as a farmer, he must get more first hand information about science. He therefore went back to the University of Edinburgh, and found that he could now learn more in a month than he could previously have done in two or three. He then got an offer of an appointment in India, and the credit of organising the Department of Agriculture

in an Indian college, the first of its kind in connection with an Indian University, is due to him. After six and a half years' stay in this country, he went back as Lecturer in Agriculture to Aberystwyth, where he was for about three years. He went from there to the Armstrong College, then the Durham College of Science, for about three years. He has been for rather more than five years Professor of Agriculture in the University of Cambridge, and recently took over the appointment of Assistant Secretary to the Board of Agriculture and Fisheries. Lord Barnard, who was in the chair, observed that, in his judgment, Mr. Middleton's career exactly illustrated the type of student whose future they ought to have very distinctly before them in considering the Report they had to make.

Prof. Middleton then gave some interesting information about the types of agricultural education in a few foreign countries which he had seen, and of which he had read. He also gave a sketch of the development of the Department of Agriculture at Cambridge.

Referring to the kingdom of Saxony, which is one of the richest agricultural countries in the German Empire, he stated that the University of Leipsic had an agricultural department where nearly 350 students were studying agriculture during the winter and summer terms. There was also a Forest school, a Veterinary college, and 15 agricultual schools of varying grades. In Prussia, there were five University Departments of Agriculture, two colleges quite of University rank, two colleges for forestry, 2 Veterinary colleges, and 16 high-class Agricultural schools. There were besides 22 lower-grade agricultural schools, 138 winter schools, and 177 special schools dealing with such subjects as dairying, farriery, horticulture and domestic economy. The Berlin Institute, he observed, was the finest of its kind in Europe, being perfectly equipped for the teaching of agriculture. It cost the State something like £27,000 a year, and it received in fees and from other sources about £9,000 a year. What struck him very much in the type of education prevalent on the continent was the extent to which not only Government but

agricultural societies took up agricultural education and research. Agricultural societies not only subsidised Experimental Stations, but they employed teachers, always well-qualified teachers sometimes associated with central institutions, sometimes with small local institutions, and sometimes itinerant teachers who went about giving advice to members of the society. These teachers, though not "practical" men in the English sense of the term, had got to go through a prolonged course and pass an examination, and in Prussia they required at least one year's agriculture before they were qualified. In addition to these institutions for the teaching of agriculture, there were in Germany about 76 Experiment Stations, of which 46 were in Prussia and 5 in Saxony. All the agricultural institutions were connected with different states. But there was one institution at least for the whole German Empire which was of the greatest importance to agriculturists, and that was a new Institute established in Berlin for the purpose of investigating the diseases of agricultural and forest crops.

Turning to the United States of America, Prof. Middleton stated that there was first of all a Central Department of Agriculture at Washington which was partly administrative, but which *primarily* existed for the purposes of research. The funds available for this Central department were over a million pounds sterling per annum. The Divisions of the United States Department of Agriculture were the Weather Bureau, the Department of Animal Industry, the Bureau of Plant Industry, Forest Service, Bureau of Soils, Bureau of Chemistry, Bureau of Statistics, Bureau of Entomology and the Bureau of Biological Survey, the Office of Public Roads and the Office of Experiment Stations. The last had charge of educational work and publications, its most important publication being *The Experiment Station Record*, published monthly, which consisted of an abstract of all the work on agriculture which had been done in every part of the world. His own interest in the *Record*, Prof. Middleton stated, began in India. He used it from the beginning, and found it particularly valuable to him, because it brought him

into contact with the work in the Southern States of America which was similar to the work carried on in India in cotton and tobacco growing. Each of the American States, with one or two unimportant exceptions, possessed at least two institutions for the promotion of agriculture or agricultural education; one was the Land Grant College, and the other the Experiment Station. The leading object of the Land Grant College was to teach such branches of learning as were related to agriculture and the mechanical arts, including engineering, etc. The idea was to make them useful as professional colleges for the people of the United States. In 1904, there were 2,700 teachers in these Colleges and 56,000 students. Of the students, 5,000 only were taking a four-years' course in agriculture, while about 6,000 were taking shorter courses. These Colleges, recognising the fact that the whole subject of agriculture was too wide a subject for one man, required of the students to specialise from the beginning in animal husbandry, or plant husbandry, or some other department of agriculture or horticulture. The University and College education of the United States have only become successful since the Experiment Stations began their work, and since the results of the work permeated the Colleges.*

Turning to India, Prof. Middleton stated that, during recent years, very great progress had been made, as the result of the scheme laid down by the Government of India for the expansion of the Departments of Agriculture. In pursuance of this policy, the Imperial Agricultural Research Institute at Pusa was established and every Province has now an institution for agricultural education, in addition to Experiment Stations for research. All these were founded and paid for by Government, excepting the Tata Institute which was the outcome of private munificence.

We must conclude this very inadequate review by repeating that the volume is full of information of interest to all concerned with agricultural education.—(C. S. RAGHUNATHA RAO.)

* More detailed information about the Land Grant Colleges and the agricultural work in the United States of America, will be found in Mr. Harwood's excellent book, entitled *The New Earth*, published by Messrs. Macmillan & Co.

UNTERSUCHUNGEN UBER NITRIFIKATION. (INAUGURAL-DISSERTATION ZUR ERLANGUNG DER DOKTORWURDE DER HOHEN PHILOSOPHISCHEN FAKULTAT DER GEORG-AUGUSTUS-UNIVERSITAT ZU GOTTINGEN—BY LESLIE C. COLEMAN.)

THE question of the influence of dissolved organic matter on the course of nitrification in soils has been one of the highest interest ever since Winogradsky isolated the nitrifying organisms in 1890 and showed that they did not require organic matter for their development. Nevertheless, remarkably little work has been done hitherto in the direction of its elucidation. The thesis before us is a contribution to this end and throws most valuable light on much that has hitherto been obscure.

In a paper published in 1899,* Winogradsky and Omelianski give the results of a number of experiments on the effect of dissolved organic substances on nitrification in artificial culture, from which they draw the conclusion that all such substances act as "antiseplika" towards nitrifying bacteria. In spite of its general acceptance, it has always been very doubtful whether this conclusion could be generally applied in considering what goes on in the soil, not only because we know that nitrification actually does proceed in soils containing considerable amounts of organic matter more or less dissolved in the soil water, but also because experiment has shown that the rate at which it proceeds, particularly during the first stages after the nitrifyable material is added, is more rapid in soils of high humus-content than in those in which the humus-content is low.† It has also been shown that the physical conditions under which nitrification takes place exert a considerable influence on the effect of dissolved organic matter on its progress, and the obvious difference between such conditions in artificial culture and in the soil has rendered it extremely doubtful whether Winogradsky and Omelianski's conclusion does not require considerable modification in order to be applicable to what occurs in nature.

* Centralbl. f. Bakt, &c., Abt. II, Bd. V, p. 329.

† Muntz and Laine, Compt. Rend. CXLII, 1906, p. 430.

The present author has, therefore, re-examined the whole question. In his earlier experiments, samples of soil taken direct from the field are treated with known quantities of ammonium sulphate and the organic substance under investigation and the rate of nitrification in various intervals of time determined and compared with precisely similar samples to which no organic substance has been added. Later, sterilised soil and sand are used as substrata, the necessary amount of ammonium sulphate added, and inoculations made with pure cultures of both nitrite and nitrate bacteria. The first and chief organic substance examined is dextrose. This substance had previously been shown by Bazarenski * to have a distinctly stimulating effect on nitrification and, therefore, presented itself as particularly interesting for investigation. Dr. Coleman shows definitely that dextrose, in quantities which, according to Winogradsky and Omelianski, stop nitrification entirely in culture solution, acts very beneficially in soil under normal conditions of temperature and moisture. This beneficial action is most apparent in the first two or three weeks, after which it declines and may eventually appear to be transformed into an inhibiting action, but it is shown that this apparent inhibition is actually due to denitrification which sets in more readily in the soils containing the dissolved organic substance. It is also shown that an excess of moisture, and the consequent partial or entire lack of aeration favours denitrification to such an extent that the beneficial effect of dextrose on nitrification may be entirely nullified even in the early stages. It seems clear that this accelerated action of denitrifying organisms explains the apparent inhibition of nitrification by dissolved organic matter in the latter stages of previous experiments in which soils, or substances of a similar physical nature, have been used as culturable substrata, and in the early stages of those experiments which have been conducted in liquid culture.

In the experiments with pure cultures of nitrite and nitrate bacteria, these results are confirmed, and it is further shown that

* Diss. Gottingen, 1906.

the beneficial action of dextrose is accompanied by a partial or complete disappearance of that substance.

The explanation of this stimulating action of dextrose is very fully discussed and examined, but no definite conclusion is arrived at. In the course of seeking for such explanation, a long series of experiments is carried out on the assimilation of carbon dioxide from the atmosphere by nitrifying bacteria and it is clearly shown that both the nitrate and nitrite organisms obtain their carbon initially in this way, but it seems extremely probable that in the latter stages it is derived from the CO_2 set free by the decomposition of the carbonates in the substratum by the acid produced. It is shown that dextrose cannot replace the CO_2 of the atmosphere as a source of carbon and the theory that it acts merely as a tonic stimulant (in a similar manner to that in which small quantities of poisons react on many forms of life) is rendered extremely improbable from the facts that the accelerated action is accompanied by a disappearance of the dextrose and that other nearly allied organic compounds do not produce a similar effect. It is true that the stimulating action might be induced by a decomposition product of the dextrose, but this is not indicated by the experiments on the action of calcium acetate and butyrate which the author describes, and it is difficult to imagine how such decomposition could take place in pure cultures. In this connection some experiments with alcohols and other compounds which are presumably intermediary between dextrose and the acid salts should be well worth making.

It is remarkable that both cane-sugar and lactose appear to have very little action on nitrification when added to soil. As Dr. Coleman points out, if the beneficial action of dextrose were due to its products of decomposition, we should expect a similar action from cane-sugar; and the same thing might be anticipated from lactose but if, on the other hand, the sugars are inverted by micro-organisms, as the author surmises in the case of cane-sugar, surely we should expect the dextrose produced to exert the same action as it does when added direct to the soil.

None of the other non-nitrogenous organic substances experimented with seem to have any very appreciable action on the course of nitrification, whilst the nitrogenous ones have a distinctly inhibitory effect.

As a result of these considerations Dr. Coleman inclines to the opinion that dextrose acts as a source of energy to the nitrifying bacteria, which energy is expended in carrying out the oxidation of ammonia or nitrates as the case may be. But it is clear that much more work is required on the subject before a definite view can be expressed.

If dextrose acts merely as a source of energy to the nitrifying bacteria, other six-carbon sugars should have the same effect, and it would be of value in this connection to trace the action of levulose on nitrification in order to determine if the configuration of the dextrose molecule is of any specific importance in the matter. An effort should be made too to trace the changes which dextrose undergoes during the nitrification process: difficult though the task might be, owing to the small amounts of dextrose dealt with, it should not be unsurmountable if sufficiently large quantities of sand or soil are taken to start with.

At the conclusion of his paper, Dr. Coleman records some experiments on the influence of carbon disulphide on nitrification in soils. He finds, as others had found previously, that this substance at first leads to inhibition, but at later stages to a considerable acceleration of nitrification, and he ascribes the action to a direct stimulation of the nitrifying bacteria.

This matter is of particular interest in connection with the increase in fertility which has been shown by several investigators to take place in soils treated with CS_2 and other antiseptics. It would be of the highest interest to determine whether this increase in fertility is connected with a direct stimulation of the nitrifying bacteria or with the suppression of foreign bacteria in the soil to the advantage of those favouring fertility, perhaps the nitrifying organisms. In either case the increased oxygen absorption which Darbishire and Russell* have shown to accompany this

* Journal of Agricultural Science, Vol. II, p 305.

increase in fertility would presumably be apparent, but series of experiments on the action of antiseptics on nitrifying organisms in pure culture carried out in sterilised soil or sand should throw some light on the point.

It is extremely difficult to do justice to so detailed and excellent a piece of work as this of Dr. Coleman's in a short review. It is a type of what such work should be, lucid and full of suggestion for further investigation. It does the highest credit not only to its author but also to the German University system which makes the production of so valuable a contribution to knowledge incidental on the award of a degree.—(C. J. BERGTHEIL.)

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ANNUAL REPORT OF THE EMPRESS AND BUND GARDENS, POONA, FOR THE YEAR 1907-8.

IN the year under report the management of the Gardens continued to be efficient. The seed business was quite as extensive as in former years and the benefit of this trade extends to many parts of India. A number of new plants of economic and botanic interest were added to the stock of these gardens.

The fruit tree did not yield so well as in some former years owing to an unfavourable season. Over 400 new vines were planted. Vegetables are grown on a large scale.

The report under notice makes prominent mention of the successful use of the following remedies recommended by the Imperial Entomologist and Mycologist for the treatment of garden pests :—(1) Bordeaux mixture for checking the white fungoid disease of oranges and limes ; (2) Kerosine emulsion, soot and tobacco decoction for destroying cochchafers and caterpillars of various kinds ; and (3) tobacco powder for killing a kind of slugs that were eating up the bulbs of Eucharis lilies.

The experimental Botanical section is progressing well. The accounts for the year under report show a deficit of Rs. 116-12-11, but it is covered by the last year's balance of Rs. 2,493-7-4.—(EDITOR).

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